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THEORY

OF

THE WINDS.

BY

CAPTAIN CHARLES WILKES, U.S.N.

READ BEFORE THE AMERICAN SCIENTIFIC ASSOCIATION AT PROVIDENCE, AUGUST 20TH, 1855.

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ACCOMPANIED BY A

MAP OF THE WORLD,

SHOWING THE

EXTENT AND DIRECTION OF THE WINDS.

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TO WHICH IS ADDED,

SAILING DIRECTIONS

FOR

A VOYAGE AROUND THE WORLD

BY THE SAME AUTHOR.

Second Edition.

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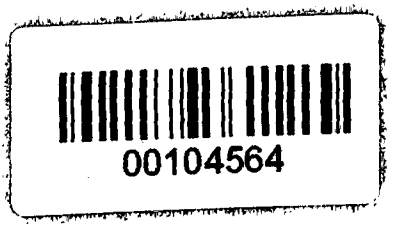

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INTRODUCTION.

"THE THEORY OF THE WINDS," which is now for the first time published, has been prepared for several years, and is printed in the Hydrography, being the XVIIth volume of the Government Edition of the United States Exploring Expedition.

Many delays incident to the publication of such an extensive work have taken place, both in the preparation, engraving, and printing, which have been beyond the control of those engaged in its superintendence. But, even the part that has been printed is, as it were, a sealed book—for there are only one hundred copies ordered by the Government for the use of the world!

In order to remedy this omission, and having officially printed the Hydrography, I feel at liberty to give a part of that volume a wider circulation in the present work, containing the Theory of the Winds, with the addition of Sailing Directions, derived from my own observations, made on the passages of the Exploring Expedition from port to port, during its four years' absence. Annexed to the pamphlet is a Map of the World, showing the extent and direction of the surface winds, — and on it are traced the most advantageous routes for vessels sailing, whether by the east or west. Among these, I would particularly call the attention of navigators to the new Equatorial route from the China Seas, through the Sooloo Sea, to the eastward, and towards the South Pacific, which will be found explained in the text.

Subsequent investigations have served to assure me of the truth of this Theory, based, as it is, upon the laws of nature.

CHARLES WILKES.

WASHINGTON, *December*, 1855.

THE

THEORY OF THE WINDS.

WINDS.

THE THEORY OF THE WINDS has been so long considered as established, that it is with some hesitation I venture to question it; especially after it has been adopted by many very distinguished men of science.

Yet, however presumptuous it may appear, I cannot persuade myself that the received theory is either satisfactory in whole or in part. It will be my endeavour, in this chapter, to exhibit the causes and effects, and to explain them more in accordance with the facts accumulated by observation.

In order to place the subject more fully before the reader, I will briefly recite the versions of the present adopted Theory of the Winds, viz.: "That currents of air owe their origin to any circumstance which has a tendency to disturb the equilibrium of the atmosphere.

"Heat is the chief cause of the atmospheric currents; for, wherever there are two adjoining regions unequally heated, there is produced an upper-current of air proceeding from the warmer to the colder region, and an under-current in an opposite direction. Now, as this state of matters exists on the surface of the globe, where the mean difference of temperature between the regions of the Equator and those of the Poles amounts to upwards of 82°, and as the inequality is nearly permanent, its effect is, to produce a constant interchange between the polar and equatorial regions."

"Thus a cold and dense under-current from the Poles replaces the rarefied air of the Equator, which, ascending and forming an upper-current, flows towards the Poles, north and south, in order to restore the equilibrium of the atmosphere.

"It is known that the earth revolves on its axis, in a direction from west to east, increasing from the Poles to the Equator, where it attains a velocity of 1000 miles per hour,—so that the air, in passing from the highest latitudes towards the Equator, progressively arrives at regions

of increased rotary velocity; and, as they cannot keep pace with this increase of motion, they necessarily hang back, and form currents flowing in a direction opposite to that of the rotation of the earth, or from east to west, and thus, by these combined efforts, the northern and southern currents of air are deflected and modified, so as to become the permanent northeasterly and southeasterly currents, forming the magnificent phenomena of the Trade Winds.

"The southwesterly winds, so prevalent in the Atlantic ocean, between the latitudes of 30° and 60°, are produced by the upper-current being drawn down to supply the superficial current which goes towards the Equator; and as it has a greater rotatory motion than the earth in these latitudes, it produces a southwesterly wind. The same is the case in the southern hemisphere, where northwesterly winds prevail.

"The theory is summed up, that whenever the air has greater velocity of rotation than the surface of the earth, a wind more or less westerly is produced, and when it has less velocity, a wind having an easterly tendency results.

"Thus there is a perpetual exchange between the different masses of the atmosphere,—the warm air tempering the cold of the higher latitudes, and the cold mitigating the heat of the lower.

"The difference of temperature puts the air in motion, and the direction of the resulting wind, at every place, depends upon the difference between the rotary motion of the wind and the rotary motion of the earth. The whole theory of the winds depends upon these circumstances.

"There are two currents of air constantly flowing from the Poles towards the Equator; and, in order to supply the Trades, the air which they keep in motion must return by some channel to the place near the Poles. If this were not so, these winds would soon exhaust the polar regions of atmosphere, and pile it up about the Equator, and thus cease to blow, for want of air to make more wind of. This return current, therefore, must be in the upper regions of the atmosphere, at least until it passes over those parallels between which the Trade Winds are always blowing on the surface. But it is held that the particles of air from the Poles travel in the upper regions of the atmosphere until they get near the parallel of 30°. Here they meet with the particles which are travelling from the Equator to the Poles. They press against each other, neutralize their motion, and produce a calm. Thence come out two surface currents, and the air to maintain them comes by the downward current, from the superincumbent air of this calm region."

I believe I have thus given the different explanations of the theories of the currents of air, excepting the theory of Dr. Halley, who ascribes

the Trade Wind to the current of air following the sun in his diurnal motion to the West.

These theories seem to have resulted from the phenomena of the Trade Winds, which appear, from their vastness of volume, permanency, and apparent constant direction, to be considered the active and permanent cause of the circulation of the atmospheric currents, instead of one of the effects which heated or rarefied surfaces would naturally produce, thereby losing sight of the one great cause in which all agree, viz.: that heat is the great destroyer of the equilibrium.

The result has been, that arguments and hypotheses have been adduced to account for the supply to this great current from the colder regions. Currents and counter-currents, both above and below, have been assigned to carry back the accumulation, and to restore the lost equilibrium;—so that the facts connected with the phenomena of the Trade Winds appear to have been entirely lost sight of.

It will be my endeavour, in the sequel, to show how these theories will stand the test of facts; and to controvert them by adducing proof and reasons that the causes which produce the effects witnessed in the movements of the atmosphere are different from what these theories represent them, and that they are wholly independent of, and sufficient to account for, and explain the phenomena which exist, without having recourse to rotative causes — and are more in accordance with science, and in conformity with the simplicity, the beauty, and order of creation established by an All-wise Being, who directs and controls the winds, brings the seasons round in their due order, replenishes the earth with refreshing showers, and supplies the wants and conduces to the happiness of all His creatures.

Now, in order to make my views more clearly understood, they may be briefly expressed in the following axioms: —

1st. That the atmosphere, when of equal temperature and dryness, will remain at rest, or a calm exist.

2d. That if the atmosphere is disturbed by any change of temperature, the denser and colder portion seeks the warmer from every direction, to restore the equilibrium in the most direct lines it can follow.

3d. That heated air, unless confined and forced, never tends towards a denser and cooler area; but when free, it always rises or falls to the area, where its gravity and temperature will restore the equilibrium.

4th. That currents of air may pass in opposite directions without mixing, provided they lie according to their specific gravities; but they can never pass through or across each other without commingling.

5th. That currents of air are influenced and disturbed by electricity.

On this basis we think that all the phenomena of the Winds may be ascertained and explained.

Great stress, in the Theory of the Winds, has been attributed to the rotary motion of the earth, in producing the direction as well as the apparent velocity of the Trade Winds.

I cannot believe that this cause has an influence on any surface winds.

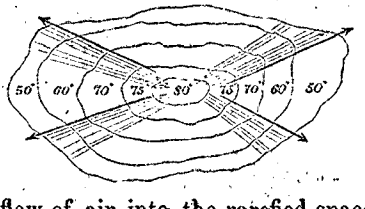
In all cases, the progression of wind, or currents of air, is always from the point to which they blow, or following the area of heat as it recedes. The origin of wind is at the area, or line of greatest heat. On those sides where the greatest density exists, it flows longer and with greater velocity to the heated area. On the others, it follows and recedes with the temperature.

The land and sea breezes furnish a beautiful illustration of this. They begin at the shore, where the line of greatest heat is — thence they flow towards it from the sea, while the heated line recedes to the interior. When the limit of heat is reached, the breeze declines, and the equilibrium being restored, calm is produced. When the land breeze in its turn prevails, the same thing occurs in reversed order. It is well known that the Monsoons first begin near the intersection, or the separation of land and sea.

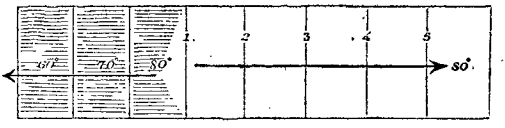
The southwest Monsoon is felt at the heads of the Arabian Gulf and Bay of Bengal, and on the Coast of China, nearly a month previous to its commencement at the Equator. As the heat of the land increases, the air follows the receding heated areas; while it flows in from areas yet more and more remote, retrograding towards the southwest or opposite side.

The northeast Monsoon, in like manner, begins at the south nearly as much in advance as the southwest Monsoon, though it retrogrades in a contrary direction; and it is well known that the northeast winds between Portugal and Madeira are first felt at the latter place — while the southwest winds are experienced on the Coast of Portugal before they are felt at Madeira or the Canary Islands.

To make the progression of the winds more clearly understood, the accompanying diagram will exhibit the action of the currents of air. The central space is supposed to be at the temperature of 80°; the next outer line represents 70°; the next 60°, 50°, 40°. Now, the flow of air into the rarefied space of 80° will be from all sides — first from the 70°, then the 60°, and then 50°, 40°; thus having a retro-

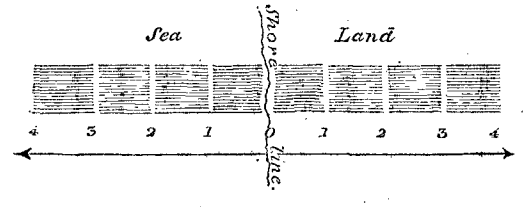


grade or backward motion from the centre. As soon as the temperature falls, the air will flow in with a less velocity, but it will continue until the temperature attains the minimum, when there will be an equilibrium, and consequently a calm. This is supposing the rarefied space to occupy a central position, but it may be oblong, or the area of heat extend over a whole country. In this case, as the temperature falls, the area of heat will recede, and the current of air will follow after the receding heat, whilst it flows from the quarter where it is colder and denser, retrograding. The annexed diagram will more clearly exhibit my meaning: —



On the left the temperature diminishes, and the flow is first towards the 80°; when it falls to 70°, the more rarefied space has receded to 1, which in its turn is reduced, the air following and flowing in to 2; thence in like manner the flow of air follows to 3 and 4. In this way extensive tracts of country are swept over by the same winds, and according to the difference of temperature will be the velocity of the currents.

As the land and sea breezes are familiar to all, and are well known to be caused by the alternate heating and cooling of the atmosphere over the land and sea, an illustration of their action, perhaps, will make the progression more clearly understood: —



The shore, or dividing line, is that of the greatest heat. In the sea breeze the flow is first from 1 to 0, which brings the 0 to its temperature; then 0 recedes to 1, followed by the cooler air of 0; and so on to 2, 3, and 4, until the temperature of the land is reduced to the temperature over the sea. Then, the same operation takes place from the land, and the air over the sea attains a like temperature; at the changes, be it of short or long duration, a calm ensues.

Before proceeding to the consideration of the subject of the winds and vapours, I shall show what is the actual state of the earth's surface

as to temperature, the great cause, admitted by all, of the aerial currents.

For this purpose, I have divided the earth into five zones (see annexed map), viz.: Two frigid, two temperate, and one torrid zone. The frigid zones are those from the Poles to the 60th parallel; the temperate zones are those between the 30th and 60th parallels, north and south; and the torrid zone embraces 30 degrees on each side of the Equator, or the space between the Tropics. The extreme difference between these is more than 80° Fah.;—that of the frigid zones being considered as the seat of perpetual congelation, while that of the torrid rises to a temperature above 80°. It is impossible to inspect this map without being struck by the width of the belt of heated water which surrounds the earth, comprising nearly the entire space within the Tropics. At the same time, it will be observed that the preponderance of these heated waters lies in the northern hemisphere.

It would be foreign to the subject, in this place, to institute the inquiry, whence do these waters derive their heat? But the question may be so far answered, that this heat cannot be wholly from the sun; and it may be questioned if his heating rays have any other effect upon them than to increase the evaporation.

Many philosophers assert, that what heat is derived from the sun's rays is again returned to the air by radiation. If such is the case, it is not by accumulation from that source that this heat can have been originated.

How great must be the evaporation which is constantly taking place, both by day and by night, from these heated waters — and what an immense rarefied area is here exhibited to view, to destroy the equilibrium in the atmosphere, and generate the vapors. In it we see ample cause for the wonderful effects which we witness in the phenomena under consideration, and which must continue so long as the same cause prevails.

It is thus evident that on this planet we have a continuous belt of heated water around the globe.

If we recur to authorities, we are informed that the air is an elastic fluid, acted upon by the same laws of gravitation as the more solid particles of matter. Consequently it will remain at rest from its vis inertia, provided an equilibrium of temperature is insured, and will be carried with the earth in its revolution.

That the rotary motion of the earth cannot have any effect upon the surface currents of air, is also fully evident, by the fact of the prevalence of westerly winds at the same time that we have easterly winds within the Tropics moving in opposite though parallel directions. Now, if this

rotary motion was felt in one direction, it ought to operate in the other, and to produce a westerly wind, to be felt on the surface at the Equator, moving at the rate of 1000 miles per hour, it would be necessary for the wind to have greater velocity. This will be readily seen to be impossible — for the greatest velocity that wind has been known to attain in a hurricane, is short of a hundred miles in the same time. We therefore consider that the earth must carry with it in its revolution a large part of the atmosphere which, undisturbed by heat, would remain quiescent, and be free to move in any direction. If this were not the case, none but easterly winds would prevail. But it is known that we have strong breezes from the west within the Tropics and between the Trades, and in the Indian and Pacific oceans from the west and northwest, where they continue for months together.

The hypothesis I have quoted assigns the rotary motion, combined with the aerial currents from the Poles, to give direction and to be the cause of the Trade Winds—in other words, forming the mighty engine which it is supposed acts to keep up the circulation of the whole atmosphere. Can it be possible that the same particles of air are carried from such great distances only to supply these great aerial currents, when we perceive that these particles must be subjected to the surface winds, calms, and heated areas, undergoing all the changes air is liable to, from moisture, as well as heat, in its passage.

Now, the direction of all winds is towards the heated areas of the ocean, and the same tendency likewise prevails towards these areas on the land, unless a high range of mountains should intercept their flow. And according as the difference of temperature existing in the near or remote regions is greater or less, will the currents of air or winds tend towards them with greater or less velocity. When the air thus induced becomes heated, it rises with the vapor to the upper and colder regions, the moisture is condensed, and the formation of clouds is the result, which are borne off in the direction of the currents of air.

The air of the upper regions, we conceive, seeks in like manner the nearest rarefied spaces which may exist, and passes off either to the north, south, east, or west, or changes its relative position in altitude, according to its specific gravity or temperature.

The ocean occupies three-fourths of the surface of the earth. It must necessarily have a greater and more extended influence than the land, and its mean temperature is 6° above that of the land.

If the great current from the Poles to the Equator, as assigned by the old theory, existed, we should find the whole course of the winds different from what they are now known to be. In order to make this more clear, I will give the direction of the currents through the regions

of the Trade Winds in the north and south Atlantic. On the confines of the Trade Winds, or between the latitudes of 28° and 30°, calms are very prevalent, both north and south, extending along their limits. Proceeding south, the wind, instead of coming from the north, is from the east. Advancing southward, it shifts to the east northeast, then northeast, north northeast, and finally it becomes north, or at right angles to the Equator, and afterwards falls calm. Now, it cannot but be perceived that this is almost in opposition to the Theory — for if the wind had derived its direction from the rotation of the earth, and its current towards the Equator, its curve would have been different, and the current of air would be unable to change its direction, having the same vis inertia as other matter. From this it is to be inferred that the Trade Winds cannot be caused by the rotation of the earth, combined with surface currents of air coming from the Poles to the Equatorial regions. Moreover, it would be the reverse of the direction which they now take, and we now know that the currents of air have not sufficient force, nor the direction to combine, with the rotary motion of the earth, to produce or maintain a diagonal course of any current of air, much less one as great as the Trade Winds.

Let us now examine the extent or prevalence of the limits of the Trade Winds. The northeast Trade Wind of the Atlantic is comprised within the space between the 9th and 28th degrees north latitude on the east, and the 12th and 25th parallel on the west, and between the meridian of 18° and 90° west longitude. Its northern edge passes westward, cutting the Tropics at 75° west, and thence along that parallel to 90°, where it ceases. Its southern edge, from the parallel of 9° north latitude, and 30° west longitude, tends towards the parallel of 12° in the longitude of 60° west; then passes along the coast of Guiana in a west northwest direction through the Windward Islands, till it reaches the peninsula of Yucatan, in 87° west longitude; thence it passes into the Gulf of Mexico, and is lost.

The most eastern point of the northeast Trade Wind of the Pacific ocean is found in the meridian of 109° west longitude, and in 4° north latitude. From there it extends in a northwest direction to the longitude of 120° west on the parallel of 26° north latitude. Its northern boundary runs nearly on this parallel to the west until it reaches the meridian of 145° east, to the northward of the Ladrone Islands, where it is merged in the northeast, or intercepted by the southwest Monsoons prevailing in the Western Pacific. Its southwestern point is in 10° 30′ north on the same meridian. The width on its western end is 360 miles less than on its eastern. Its southern edge or boundary makes a slight curve between its eastern and western limits.

The southeast Trade Wind of the South Atlantic has its southern and eastern limit in 28° south latitude, and 10° east longitude. Its southern boundary tends westward to the meridian of 15° west longitude, where its western boundary begins; turning north, extending to where the 35th meridian west cuts the Equator, it thence continues as far as 3° north latitude. Its northeast terminus lies between the longitude of 15° and 36° west, in the latitude of 5° north and the Equator.

The southeast Trade Winds of the Pacific are distant from the coast of South America 300 to 350 miles. The extreme southern limit may be given in 30° south latitude, in the longitude of 80° west. On its eastern boundary it has the same curve as the western coast of South America. It passes to the west of the Gallipagos to the latitude of 4° north. Its southern edge varies as much as 10° in latitude during the opposite seasons of the year. The southern limit runs from the parallel of 30° to 26°, and between the longitudes of 90° and 180° west. This boundary is oftentimes much contracted and disturbed. It sometimes describes a curve as far as the parallel of 15° south, in the longitude of 140° west; thence towards the Equator in 170° east; there it is bounded by the northwest Monsoon of the Pacific ocean; — and during the period of the southeast Monsoon of New Holland, this Trade Wind becomes apparently merged in it. At times it may exceed these limits to the west, but does not so usually. The winds near the western terminus are light, with frequent calms, and variable at all seasons. The northern and western boundary extends across the Equator to 3° 30′ north latitude, and on that parallel easterly to the meridian of 95° west. Of all the Trade Winds, this is the most uncertain; it blows for several days together strong, when it intermits, and is succeeded by calms or light westerly winds.

The northwest Monsoon, and the southwest wind of the Southern Pacific, when the sun is in southern declination, prevent these winds from extending to the south, and confine them to the limits above described.

The southeast Trade Wind of the Indian ocean is found to prevail at the distance of 350 miles from the west coast of New Holland, between 11° and 30° of south latitude. On the latter parallel, it continues to the west as far as 43° east longitude, or nearly to the meridian of Madagascar. Its northern limit describes a curve from the 90th degree of east longitude to the middle of that island, touching the 11th degree of south latitude; the north and south sides approach nearly to a point, forming the western terminus.

Having thus given the extent of the several Trade Winds of the oceans, I shall give those of the Monsoons, which will also be found represented on the map.

The Monsoons differ materially in character from the Trade Winds. They are more equable, without the squalls, and undergo little variation during the day and night. They have their regular increase and decrease until they cease. They are more allied to the land and sea breezes, and result from the same cause. Indeed, they may be said to be such on a large scale, having a duration of several months, instead of occurring daily. Every one who has experienced the Monsoons, cannot fail to have been struck with the great difference between them and the Trade Winds. The most remarkable Monsoons are those of the China seas and Indian ocean, called the northeast and southwest. They prevail between the Equator and the latitude of 30° north, extending on the land as well as over the neighboring seas. Each, on an average, has a duration of five months in either direction; at the changes, which occupy two months, variable winds occur.

There appears to be much exaggeration about their constancy and their course. The cause assigned for them is undoubtedly the true one, — that of the heating of the immense areas of land of the Asiatic continent by the Sun, rarefying them, and thus drawing towards them currents of air from the southwest to restore the equilibrium.

It may occur to others, as it has to myself, why should not this air be supplied from the cold countries of the north, which are nearer, and should be induced to seek these warm and rarefied areas?

By an inspection of the map, we find ample reason why this cannot take place. We will there perceive that the highest chain of mountains in the world stretches across the whole of Asia, from east to west, creating an insuperable barrier to the winds coming from the cold regions of the north beyond; and therefore the air is induced from the southwest, to flow towards the heated areas of Hindostan to restore the equilibrium, further it cannot go.

To the north of this range of mountains also lies the desert of Gobi, and on the west is the high table-land of Iran, as well as that of Syria, and the Sahara of Africa. These all induce the denser and colder air from the mountains on the east, and from the north, to supply the rarefied area which exists in those places. On the Sun's return to southern declination, these parts become cooled, when the air flows back from the northeast to supply the areas, which in their turn become heated, forming the northeast Monsoon.

The northeast and southwest Monsoons extend from the east coast of Africa over the China seas, and as far as the Marianne Islands in the Pacific. The former has more strength than the latter. In the northern parts of the China seas, the southwest Monsoon is but feeble.

There the cold and denser currents from the northeast seek the rarefied areas with more force. They prevail generally three-fourths of the year.

In the Gulf of Bengal, Arabian Sea, as well as the Bight of China, the Monsoons are not so regular as they are in the open sea. They are often light and changeable, and frequently calms prevail. This is particularly the case within the Straits of Malacca, where variable winds are almost constantly found.

The northeast Monsoon is confined to the north of the Equator. It has many interruptions to its course from the high islands which lie within its range, and create many disturbing causes, diverting it from its direction, being at times influenced by the heated areas which prevail on the large islands.

Between the Equator and the eleventh parallel of south latitude, there are two other Monsoons, known as the northwest and southeast. These are coincident in point of time with the former, undergoing their changes about the same time of the year. They blow nearly at right angles to the direction of the first, but are divided by calms. Though one appears to be derived from the other;—that is to say, during the prevalence of the southwest Monsoon north of the Equator, we have the southeast Monsoon south of the Equator; and when the northeast Monsoon blows north of the Equator, the northwest Monsoon prevails south.

This latter Monsoon extends from the 50th degree of east longitude to the east, across the Indian ocean, through the Banda and Java seas, passes by New Guinea, and into the Pacific, and at times as far as the longitude of 140° west.

The boundary of this Monsoon in the Indian ocean is not throughout on the 11th parallel, but towards the Island of Madagascar; and at its extreme eastern limit in this ocean it extends several degrees farther to the south, forming a considerable curve; a calm belt lies between it and the southeast Trade Wind. This Monsoon, in part, is diverted towards the centre of New Holland, where a large rarefied area exists during the presence of the sun.

The southeast Monsoon appears in like manner, linked with the southwest. That current of air extends from the Pacific ocean, east of New Holland, and flows to the westward in the Indian ocean, side by side with the southeast Trade Wind. Although this wind is often designated as the southeast Monsoon, its direction is not at all times from that quarter, but it frequently comes from east northeast.

The Monsoons which prevail in the Mozambique channel, between

the Coast of Africa and the high land of Madagascar, lie between latitude 30° south, extending across the Equator to the north, along the East Coast of Africa to Cape Jeddah, and half-way up the Red Sea. These Monsoons pass under the northwest Monsoon to the west of longitude 50°; the winds are light, and calms often take place. The direction is from the north northeast, and south southwest, parallel with the Coast of Africa. Their period is nearly coincident with the southwest and northeast Monsoons, north of the Equator, which causes them to be considered by some as an extension of the former; but in reality they are separated by a region of calms. They ought therefore to be viewed as distinct.

Although the great Monsoons are confined to the Indian and Pacific oceans, and China seas, yet there are several of lesser note and extent which exist on the east and west coasts of North and South America. That which claims particular interest from navigators, is on the Coast of Brazil. It is experienced from the neighborhood of Cape St. Roque to the Island of St. Catharine. Properly speaking, however, these are not Monsoons, though they have been classed and considered as such. They do not interchange their direction periodically, like the others, but only veer through several points of the compass. These changes on the Coast of Brazil are from the north, by east, round to the south, on the southern parts of the coast. They show most conclusively that the currents of air are induced towards the heated areas of the land, which become rarefied from the action of the Sun's heat upon the surface of South America.

As the Sun changes towards the south, in declination, the land of South America becomes more and more heated. The air is drawn towards these areas from the north and north northeast, along the whole ocean bordering on the east coast. It flows from the different points of the compass towards the land;—in general, perpendicular to the part of the coast, but always directed towards the heated area. This is what is called the northeasterly Monsoon, which begins in September, and continues till February.

When the Sun is returning to the north, the wind veers back again through the several rhombs of the compass, and becomes settled along the whole coast, from east by north to east southeast; still blowing towards the heated areas, they flow in almost the same direction with the southeast Trades, for which they are often mistaken.

In the immediate vicinity of the land of South America, there are also land and sea breezes. It is remarkable, when these coincide with the direction of the Monsoons, the latter are increased in strength, and the land wind which ensues after the sea breeze, is also much stronger.

It may be as well here to call attention to the fact that the winds which flow into the large rarefied areas of South America, may be said to be constant, although they vary very much in strength and direction; unlike other areas, the land is never cooled below ocean temperature, so as to produce a return current from the land to the sea.

These heated areas are supplied from the north and south, as well as from the east. The high mountain range near the Pacific coast, like those of Asia, intercept the currents of air from the east, until it rises over their barrier.

Next in importance are the Monsoons on the west coast of Mexico. The duration of the northern Monsoon is from the month of December to May. The currents of air are from the north and northwest, nearly parallel with the coast. They seek the heated waters of the Gulf and Bay of Panama. During its prevalence, fine weather is experienced—whence this season, although the winter of the northern hemisphere, has been denominated the summer of these regions. In the offing, they blow with more strength and steadiness than near the land.

When the Sun advances to northern declination, heating the land of North America from the month of May to September, the currents of air are from the south and southwest. These are the stormy months, attended with great explosions of electricity, and copious and constant precipitation, which is produced and evolved by evaporation and condensation. This causes great irregularity in these currents of air, from the colder temperature being in such close proximity to the heated waters of the ocean. Squalls and tempests prevail, which come from the high land of the isthmus, and rush with great violence over the sea, though they are of short duration.

Connected with this Monsoon, a southerly wind, an extension of the southwest Monsoon, prevails from the Gallipagos Islands to the Bay of Panama. The cause here is also quite evident. The water of the ocean surrounding the Gallipagos islands is some fifteen degrees colder than those of the Bay of Panama; consequently the air in contact with it is cooler, and we should naturally expect, as we find to be the case, the air constantly seeking this rarefied area. The current of air, therefore, between these two points prevails throughout the year; although it is a region subject to calms and very light airs; but when there is any wind, it is from the southwest.

I conceive that these are strong and sufficient proofs of the theory to which I wish to call attention.

There are also Monsoons on the west coast of South America, extending from Chili to Peru, which prevail from the northward from May

to August — and from September to April, from the south. The former period is designated the rainy season. During the latter, the winds are considered to be allied to the southeast Trade. No rain falls during this period.

The extent of this northerly Monsoon is through 23 degrees of latitude, from the 12th to the 35th degree south. This apparently is from a warmer to a colder latitude; but if we examine the temperature of the land, we shall find that it is warmer than the sea to the northward of it, and produces the same effect as in other cases. The northerly Monsoon takes place when the Sun is in northern declination. It is characterised by being light and inconstant, and as it approaches the parts of Chili south of the rainless district which exists on this coast, the condensation and precipitation are immense, evolving heat and moderating the climate. The cold and dense atmosphere of the tropical parts of Peru, which comprise the rainless district before mentioned, is then induced towards the south; the resulting current of air is therefore from the northward, and nearly parallel to the coast.

This current of air is seldom experienced in the northern parts of Peru. When it does take place, the vapor which exists in the atmosphere is made evident in the form of mist, or the "garua" of Peru.

The heat engendered by the Sun when in southern declination, causes the air to become rarefied on the Coast of Peru; and the influx of it from the south, to fill up and restore the equilibrium, produces the southerly Monsoon, which blows with great regularity.

The Monsoons of the West Coast of Africa prevail from the latitude of Madeira to the Cape de Verdes; thence south, extending into the Bight of Benin, and as far as the Cape of Good Hope, and are the next to claim attention.

They are divided into the northwesterly, westerly, southwesterly, and northeasterly Monsoons. The first three blow towards the land, whilst the last, called by the natives the "harmattan," blows from the land to the sea.

The duration of these Monsoons is very unequal; the former lasting some nine months, from March to December, while the latter rarely endures three months. Like the Monsoons of the Coast of Brazil, the direction of these winds depends somewhat on the trend of the coast and the position of the Sun in declination, by which the continent of Africa is heated and the rarefied areas maintained. The current of air rushes towards the heated areas which are nearest; and consequently, on different parts of the coast, the wind changes its direction, so that it is found to flow from the south to the northwest by the west.

The flow from the west under the Equator extends nearly across the

Atlantic ocean between the two continents, in a cuniform shape, from the month of June to September; after which time it ceases, calms ensue, and then the "harmattan" prevails from December till March, with occasional intermissions.

The character of these Monsoons is different;—that from the southward and westward is always attended with rain, while the northeast is a cold and very dry wind, flowing from the high lands of Africa. It seeks the heated areas of the ocean, but does not extend more than a hundred and fifty to two hundred miles from the coast.

There are other periodical winds which have an extensive range, but of which our knowledge is as yet very limited. I have reference to the winds which sweep across the great deserts of Africa, Asia, and America. In order to trace these, we require many more observations than we now have; but enough is known to establish the fact that the easterly and northerly winds prevail during nine months of the year, and are succeeded by those from an opposite direction. In the Mediterranean these winds which flow towards Africa have been long known by the name of the Ætesian winds.

A denser and colder aerial current also flows from the Caucasus, in southern Europe, towards the rarefied areas of the Great Desert, while the Sun pours his vertical rays on it; but, on the Sun's return to southern declination, the Desert becomes cooled, and light airs at times flow from it towards the heated waters of the Mediterranean. In Egypt, a cold current of air flows from the south during the winter months, towards that sea.

A peculiarity exists in the currents of air on the Red Sea. They flow in from the north and northwest; but their limits do not extend beyond half the length of that sea, where they become neutralised by the high temperature; and, as has been observed, the currents from the southwest Monsoon of the Indian ocean prevailing in the southern half.

Although we believe that the heated waters of the Tropics, which we have shown to exist, are sufficient to account for the flow of the aerial currents towards the Equatorial regions, we are far from denying the action and influence of the Sun.

It will be seen by the map, that these heated waters occupy a much greater area in the northern than in the southern hemisphere, which we think is the cause of the unequal prevalence of the Trade Winds, as respects their extent in latitude. It is a well-established fact that the northeasterly Trade Wind rarely, if ever, reaches the Equator; while the southeast Trade, coming from the south Atlantic, passes at times several degrees to the north of that line. The anomalies and vibra-

tions of the Trade Winds, we conceive, are caused by the Sun's heat. These have been for a long time noticed by all navigators; and we think it quite clear that the diurnal increase and decrease of the Trade Winds which always follows or precedes the Sun's course, renders these winds fitful and unsteady. The temporary heated belt and greater evaporation which is created by his rays, has an immediate influence, causing a rarefied area to follow, as it were, in his wake, into which the denser air rushes with velocity, giving rise to the extension of the Trade Winds in latitude by drawing the air from more remote parts, and sudden squalls, condensation, and consequent precipitation, and not unfrequently to a change of wind to several points for a short time, occurs in what is supposed to be the very strength of the Trade Winds. When the Sun is in the opposite hemisphere, the Trade Winds are more steady and regular, having less of a fitful character; and the squalls of wind and rain are rarely experienced.

The calm areas have been for a long time a terror to navigators, and will continue to be until they are better understood. I have designated a calm as the result of equilibrium of temperature, whether it be high or low. In the first case, it is more or less a rarefied and moist atmosphere; in the second, dense and dry.

All observations show that there are several areas of ocean where calms exist almost constantly. There are others which are periodical, and result from geographical position; while some have a daily recurrence, though well defined in limits. The areas of calms comprised within the Equatorial limit, and those on the outer borders of the Trade Winds, have also their periods of vibrations, caused by the influence of the Sun's heat. The periodical calms are those consequent upon the change of the Monsoons, and the diurnal ones are the result of the land and sea breezes. Those resulting from geographical position, are the large areas of ocean where the heat has induced an almost constant high and equable temperature, to which the flow of the currents of air are sluggish, resulting from the velocity of the ascending current, and where large areas are reduced to a very low and equable temperature by the ice which exists in the Polar regions. All calms continue as long as the surrounding atmosphere remains undisturbed. Many instances of these will be brought to mind by the daily experience of every individual.

We thus perceive that calms are frequent both in high as well as low latitudes, and play an important and essential part in the circulation of the aerial currents. Were it not for calms, in order to secure the changes of atmosphere to ensure a circulation, the heat and cold would be much greater, the changes more constant, whirlwinds and

disastrous conflicts more frequent, and the shocks to our senses unbearable, or the atmosphere would be brought to a stand-still under one temperature, and we deprived of the blessings which a free circulation gives in the constant recurring cool and refreshing breezes, so essential to the health, welfare, and happiness of man. In the first case, neither man nor nature would know repose; in the second, there would be nothing to prevent that stagnation which would engender all kinds of disease, and both animal and vegetable life would suffer,—and that order of things "which tempers the winds to the shorn lamb," so beautiful, simple, and so wisely ordained in the progressive movements of the winds in their retrograde action, would be destroyed, by which the temperature is made to increase and decrease gradually, its accumulation prevented, and not suffered to become stagnant by the one great law under which it acts, — the denser and colder atmosphere seeking the heated or rarefied areas. Knowing where the areas of the heated waters are, where calms usually take place, it will at once be perceived how these vexatious visitations to the navigator are to be avoided, and they will serve as a means by which he will be enabled to pursue his voyage and preserve his wind. All that is required of him is to regard those parts of the ocean where the high temperatures exist at certain seasons of the year, and so to navigate his vessel as to pass either on one side or the other, by which he may be assured that he will be able to take advantage of the current of air that may be flowing towards them.

It now remains to treat of the variable winds of the temperate zones, or those spaces which I have included between the latitudes of 30° and 60° north and south. It is well known in these northern and southern zones in both hemispheres, that the winds prevail from the belt of calms on the borders of the Trades in the summer months, and towards them in the winter months. This is the general course of the variables. By the old theory as quoted, it will be recollected that these winds were assumed as the return current towards the Poles, and that their direction resulted from the action of the rotary motion of the earth, and the flow to the north and south was the return current to the Poles, which they had supplied to the Trades; and were it not for this interchange, the wind, it is argued, "would cease to blow for want of air to make wind of." The modification of this system, since adopted, I regard as equally inconsistent with what takes place, viz.: that the heated air which rises from within the Tropics flows over towards the calm areas on the outer borders of the Trade Winds, there meets with another upper current from the Poles, descends to the surface, and reissues in two surface currents in opposite directions — the one to the

south, the other to the north — the former to supply the Trades, the latter to restore to the Poles what had been taken from them for that purpose. This modification of the old theory removes one obstacle,— that of the winds coming in actual contact on every successive parallel; but it creates another and, in my opinion, a greater one, viz.: a meeting and crossing at the area of calms of opposite currents of air of different temperatures without commingling. I can see no reason why the air should flow towards these belts by the upper current, descend, and reissue in different and opposite directions, affected, as it is represented to be, by the rotary motion of the earth, united with the flow to and from the Poles, whilst the impulse of motion in either direction is changed or ceases, and the vis inertia of the body of air destroyed.

Now, in the region lying to the north and south of these areas of calm, it is found that the temperature of the ocean is higher in the summer months of the two hemispheres, and that there is in consequence a flow of air from it towards the parallels a few degrees to the north and south; — those in the northern hemisphere veering from the southwest to the southeast by the south, whilst those in the southern veer from the northwest to the northeast by the north. These currents of air frequently coincide with the general direction of the variable winds in higher latitudes, the flow of which is simply induced by the difference or variations of temperature, as shown by the isothermal lines of the oceans lying between the old and new continents in either hemisphere, combined with the heating of the surfaces of those continents during one portion of the year, which induces the flow towards them to be greater. When they cool, the flow returns from them to the ocean, and this creates as well as gives direction to the alternate flow of currents of air familiarly called *the variables*, and with which the rotation of the earth can have nothing to do. The Polar winds, in like manner, circulate, caused by the unequal distribution of heat, and by the rays of the Sun during his semi-annual sojourn, as well as the evolvement of heat in the condensation of vapors, and the changes of water into ice. The order of these movements is simple, and effective in producing a thorough interchange and commingling of the atmosphere, and results wholly from the one great natural law which has been given to it by an All-wise Providence.

Having traced out the aerial currents on the surface, we will now take up those of the upper regions, which the theories quoted in the first part of this chapter represent as setting towards the Pole, "for the purpose of restoring the equilibrium, and drawing off the accumulation which would soon exist at the Equator, as well as to ameliorate the climate by diffusing heat around the Poles."

In confirmation of this upper-current theory, it is stated that the winds pass in a constant current from the southwest and northwest; but this, it appears, is only an inference from induction,—that there must be a return current to replace the air coming from the Poles, which otherwise would soon be without atmosphere. Where is the proof that these winds do prevail, and are constant?

The observations which have been made are too few to establish it, or that the air has any particular direction in the upper region. My stay of three weeks on the top of Mauna Loa, 14,000 feet above the level of the sea, did not show it. It is true the most stormy and violent winds came from the southwest, but a great part of the time the winds were light and variable, and from every point but southwest. The temperature of the winds was low; they were doubtless induced to some warmer area.

Much stress has also been laid on the fact of the descent of ashes from the volcano of St. Vincent, in Barbadoes, in the year 1812, as proving that the upper current was from west to east in the upper regions. I think it is by no means conclusive. The vast amount of heat evolved may have caused a change in the aerial currents of the upper atmosphere, or the ashes been attracted to Barbadoes by an electrical current; and full as plausible a solution may be advanced, that the ashes remained in the upper atmosphere till the earth had performed her revolution, during which period they may have imbibed sufficient moisture and loss of heat to become heavier, and descend over the region to the east, on the parallel with the two islands.

In recurring to the eruption of Cosiquina, in Nicaragua, in 1835, we find that the ashes were carried in all directions and to great distances.

It may indeed be doubted whether any continuous upper current does move from the Equator to the Poles. I have found no proof of it whatever. The upper clouds, which must move with the upper currents, have always the appearance of moving from east to west, within the Tropics. The opportunities for making these observations rarely occur. I speak, at least, from the experience I have had. I am not prepared to say that their absolute motion is such, but it is the most reasonable supposition; and if we admit that the air, in rising to the higher atmosphere, loses a part of the earth's velocity, it must fall behind, and have the appearance of moving in a contrary direction to the earth in her rotation.

Should this be the case, and all analogy would lead us to believe that it is so, yet, when we refer to the aerial voyages which have been made, we do not find anything that establishes the fact of the existence of an upper current in any particular direction.

In the celebrated voyage of Gay Lusac and Biot, they rose to the height of 13,000 feet, and were up, in their ascension, three and a half hours. The aerial current was found to prevail strong to the southeast. In the second voyage of Gay Lusac, when he ascended to the extraordinary height of 23,940 feet, and continued up for six hours, the aerial current was then from the northwest, directly opposite to the former. On this voyage, Gay Lusac, at the immense height he reached, had still the cirrous clouds above him, pointing in various directions. In both of these voyages, the most remarkable on record, we have a contradiction of the theory of the southwest upper current towards the Pole, as well as the slipping of the earth under its atmosphere. Had it been so, Gay Lusac would have landed nearly one-quarter of the earth's circumference to the westward. He returned to mother earth a little over fifty miles from where he set out.

The voyages of Mr. Wise, the æronaut, as well as others, do not prove that the aerial current is flowing from the west to the east. During the period of the year when his ascensions took place, there is generally a flow from the southwest and northwest to the eastward — that is, from the land towards the ocean; and although he states that there exists a westerly current within an elevation of 12,000 feet, I can find no proof in the publication of the voyages on which this bold and intrepid æronaut bases his remark.

The cirrous clouds ought to afford us some indication of the course of the aerial currents in the upper atmosphere. The forms which these suspended vapors assume must be more or less shaped by the aerial currents in which they exist. Frequently they are seen to undergo rapid changes. Every one who has watched these clouds, knows that they tend in all directions. These facts go to prove that although upper currents prevail, they do not follow the theory, viz.: flow from the Equator towards the Poles, or in any particular direction.

It is impossible that the air of the Tropics should carry any heat to the Poles, to modify and lessen the rigour of the northern and southern climates, as held by the old theory; — for the air, on ascending, is reduced to the low temperature of the freezing point within the Tropics, at the height of 16,000 feet above the sea, at which altitude the snow-line is constant. It is therefore evident that there is nothing to support the theory that there are "return currents in the upper atmosphere flowing from the Equator to the Poles;" and it is utterly impossible, if they did exist, that they could carry any of the heat with them which they had acquired when within the lower Equatorial limits.

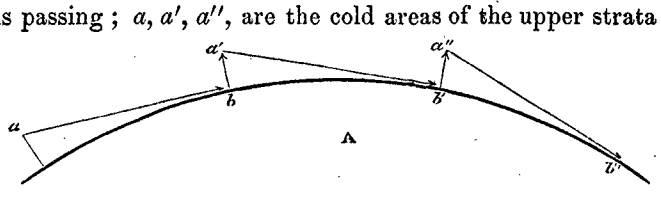
To return to the surface currents. Although the map which accompanies this chapter exhibits the flow of the aerial currents in the differ-

ent seasons, it is necessary to state from whence these currents are supplied. In order to understand their action more fully, I shall endeavor to do so.

Having satisfactorily proved that the Trade Winds do not receive their supply of air in a continuous current from the Poles, and that the return or upper current does not exist, it is incumbent to show whence they receive the vast supply and the circulation.

Lest I may not have made the interchange of the atmosphere fully understood by those who may not be familiar with the action of the currents of air, I shall now explain how great Equatorial currents are supplied and maintained. Prior to tracing them out, I will give what I conceive to be the progression of the atmosphere around the globe, from the cooler to the heated area, then ascending to the cooler upper strata, and onward to the heated area again. This may be better understood by the annexed diagram: —

A represents a part of the earth's surface over which the great current is passing; a, a', a'', are the cold areas of the upper strata; b, b',



b'', the heated ones of the surface; the long ⇛ shows the direction of the cold or dense wind passing from a to b. It then rises in the direction of the short ⇛ to a', becomes cooled, and flows off to the warm area b'; thence it again rises to a'', and follows the same alternating course to b''; but always towards the direction where it is most strongly induced. Now, these lines are all tangents to the earth's surface, and the shortest distance between the two areas. The currents of air, in this way, pass over a mountain chain, rising up to its top, and leap over the lesser Monsoons, which flow underneath, parallel to the line of the coast or mountain range.

In examining the position of the heated areas of the ocean, we find that they generally lie within the Tropics to the westward of the Trade Winds, with the exception of that towards which the southeast Trade Wind of the south Atlantic blows.

Let us take, for instance, the northeast Trade Wind.

The heated areas of the land (the Sahara) lie to the east of the Trade Winds. Vast currents of air are passing towards these, almost throughout the year. They come from the north and south as well as the east. On becoming heated over this area, they rise, lose their temperature, and are thence induced towards the nearest warmer area of the ocean lying to the west, on which they descend, some three hundred miles from the

Coast of Africa, in about the longitude of 30° west, leaping, as it were, over the currents of air and calms which prevail between it and that coast. They thence pursue their course, rising and descending, to the warm regions of the Gulf of Mexico, are lost in calms, or intercepted by coming in contact with the high land of Mexico, rise again, become cold, and pass to the west, losing their moisture by condensation before reaching the elevated and dry plains of Mexico; thence, leaping the lesser Monsoons of the west coast, they flow towards the warm areas of the Pacific, constituting a part of the northeast Trade Wind of that ocean.

The northeast, as well as the southeast Trade Winds of the Pacific, derive their great supply from the currents of air which rush, in a constant stream of greater or less velocity, over the vast plains of South America, towards the Andes; in ascending to escape, they are deprived of their heat and moisture, and are induced towards the heated waters of the Pacific, which they reach, some three to four hundred miles from the coast, in the longitude of 90° to 120°; and thence onwards to the heated areas on the western part of this ocean. The wide belt between these winds and the coast of South America is occupied by the lesser Monsoons of the west coast, over which they have passed. These winds, in their onward progress, seek the area which is the nearest and most heated, and tend mostly towards the part of the Pacific which is affected by the direct rays of the Sun, at the season.

As we have stated before, the northeast Trade Winds are found, on the eastern side of the Atlantic ocean, to be various in their directions. They are almost entirely different from the western portion; and this is considered to be a strong argument against the old theory of the Trade Winds, that they do not, where they begin, indicate by their direction the forces that are thought to produce them. In some places we see the Trade Winds checked by the temperature of other winds, or lost in calms. In others, we find them merging in a periodical Monsoon, obeying other influences, and flowing towards other areas of higher temperature. In some cases, these are but temporary, while in others, they are permanent;—both the northeast and southeast Trade Winds of the Pacific are found to deviate towards the opposite Tropic when it is warmed by the Sun's rays.

The southeast Trade Winds of the Indian ocean derive their great supply from the heated air which rises above New Holland, is cooled, and seeks in like manner the warmest area of the ocean to the west. It passes over, also, a wide tract of ocean, before it descends and becomes the surface Trade Winds.

As the Sun reaches high northern and southern declination, the air is induced towards the great currents beyond their northern and south-

ern edges; it is drawn in, as before mentioned in the explanation of the progression of wind, from beyond the belt of calms; but the supply is but temporary, and very small, compared to the vast volume that is required to keep up the circulation.

The southeast Trade Wind of the South Atlantic derives its supply from the air which rises above and flows over the southern part of Africa, and then descends at some distance from its west coast, and pursues its route towards the Equator.

In regarding the movements of winds, we invariably find, where the greatest difference of temperature exists in close proximity, there its greatest violence is experienced. Perhaps the best known instances of this are found in countries where the mountains and plains lie in juxtaposition. If we take, for instance, the winds in the south of Europe, between the Alps and the Mediterranean Sea, these are, according to Dové, "celebrated for their violence and severity." We find that this extreme rapidity of the aerial current is due to the great difference of temperature. At the same time, the wind is known to blow very strong down the north side of the Alps, being induced towards the higher temperature of the plains. In New Holland, it not unfrequently occurs that the wind flows from the northwest and west, from the interior, towards the east coast. This, we suppose, to be owing to the cold and higher air being induced to flow towards the heated area of the east coast. These winds are dry and cold, the temperature often falling from 100° to 70° Fah.; yet they are felt to be almost suffocating to the feelings — and everything within their range parts quickly with its moisture, leaving it entirely blighted.

Hot winds, so called, are liable to mislead us. If they could be traced, they would be found to be tending to areas of still higher temperature; and it is well known that they are comparatively local; — but many are so called from being dry and suffocating, rather than hot. We judge of them from our feelings, rather than test them by means of our instruments.

At other times, the Monsoons often unite with the Trades, and flow in a common direction, and, where the one wind is warmer than the other, they are found to commingle and produce precipitation.

On the ocean, where the areas of high temperature exist, the air generally flows towards them from all sides, though with greater or less velocity. In the Atlantic and Pacific oceans, we have two very remarkable nuclei of heated water, where the temperature ranges nearly to 90°, and through which the Equator of heat passes. To these the air tends, although only a few degrees above the surrounding temperature; and the currents of air, after the equilibrium is restored, cease to

move in any horizontal direction, when calms ensue. These areas of calms have various positions, but they always exist where the heat is equable, and generally hold a midway position between the Trade Winds, or between these and the variables. In both cases, they change to and fro, vibrating through a few degrees of latitude.

The calms, therefore, are the result of the restored equilibrium, and they endure as long as there is no disturbance produced by a change of temperature. These calms are another proof that the earth in her rotation produces no friction to affect motion on the air, and that the air moves with it. In the northern hemisphere, where they prevail during the summer months, the temperature is generally equable. In all places where they exist within the Equatorial belt, frequent local gusts of wind, of short duration, are experienced from every quarter. There the warm air ascends rapidly, evaporation and condensation take place, and explosions of electricity, with rain, are frequent. The period when these occur most frequently is during the season when the Sun is vertical, and his action most powerful.

The inter-tropical seas being occupied by these large areas of heated water, light winds and calms must prevail, as the air can flow no faster towards them than it ascends to the upper atmosphere. During the period when the lands adjacent to these areas become intensely heated, then the air of this Equatorial region is induced towards them in gentle breezes, in pursuance of what we believe to be the true theory.

On the land there is no difficulty in pointing out where the highest temperature exists. In some cases, however, this is more apparent than in others. In none more so than in New Holland, surrounded as it is by the ocean. During the period when the Sun is in southern declination, imparting its heat to that sterile land, the air flows towards its centre from all sides.

Travellers in the interior of New Holland are overcome with the excessive heat, and make frequent mention of the long calms which prevail. The rainless districts offer several other instances in which the winds in like manner are concentrated; but as some of these occupy high table-lands instead of a depression, they change somewhat the character and direction of the air rushing towards them in the different seasons, and become quickly cooled in the absence of the Sun.

Wherever extended plains exist, and the surrounding country is high, the cold currents of air are drawn towards these areas, — and the greater the difference of temperature, the faster will be the flow. In all these localities calms and sudden squalls predominate, and the rain frequently falls in torrents, with great explosions of electricity.

If the theory I wish to establish, of the circulation of the atmosphere,

be correct, we ought to find the winds pursuing their regular route towards the areas of ocean and land. This is the case. The ocean differs but a few degrees in temperature during the year; — the land often undergoes great changes within a day.

The great outlines of these currents on the ocean and land are given on the map; and it must be apparent to all that the circulation of the atmosphere cannot be reconciled with the old theory.

It is remarkable that the effects we witness in the northern hemisphere during the summer, do not take place in the southern Pacific; the Sun's action upon the southeast Trade Winds contracts rather than expands their limits, and causes them to veer to the northward of east, even on what is supposed to be the parallel where they should blow strongest, and with the most regularity.

Instead of the summer being the fine season of the South Pacific, it is the most boisterous part of the year; violent gales come from the southwest and northwest.

The southeast Trade Winds are interrupted by the northwest Monsoon, and their limits encroached upon by the southwest winds; both denser winds. All these winds seek the areas which are most rarefied by the temperature of the ocean and the Sun's heat, in order to restore the equilibrium of temperature.

In all countries there are local winds, but they are chiefly those which approximate to the general direction. For instance, in England, and perhaps throughout all Europe, the westerly winds are most common in the summer months. In the winter months, they have those from the north, northeast, and east; which prove, so far as Europe is concerned, that the great aerial currents flow from the colder to the warmer regions.

We now perceive that there can be no accumulation at the Equator, nor deficiency at the Poles; and consequently, that we need not recur to any hypothesis to supply the one or carry off the other, to maintain the equilibrium throughout the earth's surface, or secure the circulation and supply the great currents. Under the Equatorial limits the temperature is high; — under the areas on the outer border of the Trade Winds, the thermometer stands at temperate heat throughout the year; while within the Polar circle, during the long nights, calms prevail: then the temperature is always low and generally equable. When the atmosphere is highly heated, the weight of its column is decreased; — hence the barometer stands low. Along the area of calms, between the Trades and Variables, it stands higher throughout the year, owing to

the mean temperature being lower; but at the Poles there is less height of atmosphere; — consequently its standing is lower.

The supply for these great Equatorial currents comes from the north and south Variables and Polar regions, through the Monsoons, and alternately with greater or less force during the presence of the Sun in either hemisphere. These currents of air do not flow towards the regions of the calm areas, or from them. The calm areas maintain nearly an equable temperature throughout the year. They confine the Equatorial currents to their bounds, and their limits only extend along the Trade Winds; they do not cross the Monsoons. These move freely to the north and south between them and the continents, and flow almost continuously. Short calms take place, but they are altogether transitory in their character, and confined to small spaces, where the temperature acquires a temporary equilibrium. But the great flow is not hindered, and it is free from all barriers, and passes onward in a steady and sometimes strong flow towards the heated area, varying in duration, interchanging its particles, and ever acting under the simple but efficient law impressed upon it.

But to return to the circulation. Let us take an atom of the southeast Monsoon of the Pacific, found in the southern hemisphere, southward of the Tropic of Capricorn, near the 180th degree of longitude, during the winter season (from May to October). It will flow to the northwest, west northwest, or west, passing through Torres Straits, over part of New Holland on the south, or New Guinea on the north; thence over the Banda and Java seas into the Indian ocean, where it will pass to the Equator at the calm area; it has then become heated, is specifically lighter, and rises to the upper strata, where its temperature is lost; thence it is induced to the northeast towards the heated areas of Hindostan, China, or Arabia, in the southwest Monsoon, and onward to the Himmalayan mountains, which intercept its course. Being unable to pass this high barrier, it must flow towards the east or the west, as it is induced, most probably in the latter direction, towards the heated deserts of Iran, Syria, or the great Sahara of Africa, it unites with the great current which passes over it, and flows onward to the west, to join the northeast Trade Wind. But if this atom should have been induced, in the first part of its route, towards the central heated area of New Holland, to restore the equilibrium, it would then have flowed into the southeast Trade Wind of the Indian ocean, thence across the south of Africa, have joined the southeast Trade Wind of the south Atlantic, and with it passed to the Equatorial calms north of the Equator; thence westward over the continent of America, to join the flow over the ocean whence it set out,— having performed more than an entire revolution; and at the average rate of six miles per hour, it would have required just the half year to

have completed this circulation. In the same way it may be shown that other atoms pass in various directions from the variables, through the Monsoons, and make the same circuit without interfering with each other, and flowing in the utmost order and harmony. These routes may be readily seen by an inspection of the map, and traced from the Polar circle into the variables, and through the Monsoons to the Equatorial currents, — and by noticing the mark on the arrow, it may be seen whether their flow is in the summer or winter season of the hemisphere. Thus the connection is formed and kept up between the Polar and Equatorial regions — not through one great current, but innumerable ones, in all directions, serving to intermingle the whole as it approaches the Equatorial heats. The variables flow towards the continents in summer, when they are heated by the Sun, and from them towards the sea in the winter. The Polar winds are in like manner circulated during half the year; in the long period of night, they lie quiet in consequence of the equable temperature which prevails. Nor must we fail to give our attention to the areas of calm. They prevent the access between the Trade Winds and variables except by the Monsoons. They constitute the barriers or walls which confine these currents of air to their proper limits, and prevent them flowing directly to the heated area; on examination, we shall readily see that, if they were permitted to do so, the circulation would soon cease, and everything become stagnant. How beautiful and how simple is the arrangement by which these barriers are maintained through an equable temperature, and the circulation kept within its proper limits!

The Monsoons form the great links of the circulation between the Trade Winds and the variables; and as each hemisphere in its turn becomes heated, the variables alternate with each other, and with the atmosphere of the regions of the Polar circles. All move in perfect harmony, exhibiting the wisdom and wonderful simplicity by which the whole is governed.

As the origin and cause of all winds is to be found at the area to which they blow, it follows that the indications in that quarter are to be regarded. The appearances to leeward, therefore, determine what the weather is to be,—the reverse to the practice of sailors, and all who claim to be weatherwise.

VAPORS.

ALTHOUGH I have contended that the rotary motion of the earth had no influence upon the surface currents of air in producing the direction of the Trade Winds, I am not disposed to deny that the rotary motion has no effect upon the Vapor surrounding the globe.

Vapor, like other matter, obeys and is subject to the same laws of gravity, decreasing with the distance from the surface.

If we suppose the earth a sphere, surrounded by water of the same temperature, it would be enveloped in vapor, in equilibrium and at rest, over the whole surface, and the pressure would be equal to the elastic force of vapor at its constant temperature. This pressure would prevent the formation or increase of vapor. No precipitation would take place, and the whole mass would be clear and transparent. If, however, the temperature should be changed, and become unequal, and the increase to take place at the Equator, the tension of vapor would be that of the minimum temperature; but as the evaporation would be in proportion, and go on continually, the condensation in like manner would be equally as rapid and as great, and the vapor would flow from the Equator towards the Poles, where the condensation would take place, the heat be given out, and the precipitation flow back to the Equator.

Now, this cannot take place so freely where the vapor is combined with the atmosphere, for it offers great resistance to the free passage of vapor, which is compelled, as it were, to filter through the air; but, notwithstanding it is retarded, evaporation and condensation will go on.

The temperature of an aerial atmosphere diminishes much more rapidly with increasing elevation than an atmosphere of vapor, as the relations of air to heat under different pressures varies from that of vapor in the higher regions, a new cause of precipitation and an increased evaporation beneath would be created. If the earth were covered with water, perpetual clouds would be experienced everywhere but on the Equator. The earth's surface, however, is divided into one-fourth land and three-fourths water; and as the land supplies but a small quantity of vapor, it produces a great change. Vapor tends to distribute itself according to temperature and tension over the whole surface. Vapor formed over the ocean will therefore press towards the

land, and towards the colder parallels, in order to obtain an equilibrium. Now, if this vapor, in its progress, be influenced by the rotary motion of the earth, it must distribute itself more freely and in greater quantity to the west, in opposition to the rotation; or it will flow, so to speak, to the west, without interruption; or, which is the same thing, the earth glides under it and leaves it behind. When it encounters the land, if the temperature is sufficiently low, it will be condensed; but if it should be higher, then it will be expanded and pass over the land until it meets with a change of temperature. It will then be condensed and precipitated. This generally occurs when it comes in contact with any high mountain range.

The natural course of vapor is then from the east to the west—consequently, the vapor from the oceans, seas, and lakes, which lie to the east, supply the vapor or moisture to the land on the west; — hence it follows that the continent of North and South America receives its great supplies of rain from the north and south Atlantic ocean, while Asia, Europe and Africa derive theirs from the Pacific and Indian oceans, and inland seas.

The particles of vapor move over each other without friction,—and vapor is impelled by the law of its distribution from the Equator towards the Poles. It meets with resistance in the atmosphere, whether the latter is at rest or in motion. If the course of the wind coincides with the direction of the vapor under its own pressure, it will be accelerated; but if adverse, it will be somewhat retarded. Nevertheless, it would seek to distribute itself, agreeably to its own laws, from the Equator towards the Poles, for the purpose of maintaining the equilibrium.

The law by which vapor disseminates itself is in direct opposition to what the currents of air are known to follow, viz.: from the warmer areas to the colder ones, instead of the reverse. We are not aware of the great flow of vapor, as it passes almost in an invisible state, and is not developed until the temperature is so far decreased as to cause condensation, when it becomes evident in the form of clouds, fog, &c.

It has been shown satisfactorily that the atmosphere cannot carry any heat to the Poles, if the upper current did exist. Therefore, it can have no influence in ameliorating the climate there. But with vapor it is different. It carries its heat in a latent form, and retains it till it reaches the areas where it is required, and there it is given out by condensation. This, we think, moderates the cold of the northern and southern hemispheres.

It is almost impossible to obtain by experiment the height at which vapor exists. I have made many attempts to ascertain the height of

the vapor plain by the vegetation, which varies in different latitudes from 1200 to 4000 feet. Whether it maintains a constant position, has not yet been determined; but that it does so, is very probable. In calms and during easterly winds, high peaks or mountains are seen capped with clouds, which mark the vapor plain. These are only observed in calms or easterly winds. With westerly winds, their outline is clear and well defined — another proof, if it were wanting, of the flow of vapor from the east to the west.

As we ascend from the surface, as gravitation decreases, we believe that the atmosphere of vapor is retarded, or falls behind; or that the earth slips from under it, leaving it to the west. If this is so, the several meteorological phenomena connected with vapor can be readily, simply, and, we think, satisfactorily explained.

The phenomenon of rain, it is well known, is produced by the commingling of two masses of atmosphere of different temperatures, when precipitation takes place. This is more or less copious according to the quantity of moisture or vapor which is held in suspension by them. The question as to how this vapor is carried, and whence it is brought, and how so equally divided, has excited the curiosity and admiration of all.

It has been very naturally supposed that the clouds transport this moisture from one place to another; but, when we come to investigate, they are but the outward evidence that there is vapor in the atmosphere; the immense quantity of rain which falls, and the small amount which the clouds can hold suspended, satisfies us that but a part of the vapor can be borne by the clouds, and that the large supply must be held suspended in the atmosphere: though invisible, we know it exists there.

We do not entertain the opinion that the clouds, carried by the currents of air, can bear the moisture or rain from distant regions to fertilize a country; the local influences prevailing on the route would controvert, in our opinion, such a theory; it would be impossible for so large a quantity of water as frequently falls to remain so long suspended in the form of vapor through the various climates, without undergoing condensation and precipitation; and the time necessary to transport it, under the ordinary velocity of the winds, forbids it; besides, the supply would be at all times precarious, from the varying temperature of the climates which it would have to pass through on its transition from one parallel to another. On this account, and for other reasons, it seems impossible to subscribe to the theory of "rain-bearing winds." It must be distributed in other ways.

We have already referred to the distribution of vapor under its own

law, and can readily account for the supply of rain; nor are we at a loss to point out the reservoir which affords such copious supplies.

The evaporation from the great oceans whence the supply of vapor comes, takes place at all seasons of the year, particularly when the Sun is vertical. It flows to the west, under its law of distribution, and may possibly be assisted by the rotation of the earth. This flow continues constant, though invisible, throughout the year, from the water to the land. The temperature of the ocean, we know, remains nearly the same, but the land is subject to great variations. So long as the temperature continues the same, the vapor is held suspended — consequently, we have but little rain on the ocean; but when it encounters the land, if the heat over it is greater, it is expanded and passes on — if less, condensation takes place, and precipitation ensues. Thus the supply is afforded in inexhaustible quantities in the most simple way — one that is alone dependent upon a change of temperature. From these causes rains of shorter or longer periods are produced. Local winds, and even fresh gales, are the result of the heat evolved by the condensation of the vapor, which forms large rarefied areas, into which the denser air flows with greater or less velocity.

According as the air is more or less surcharged with vapor, are we liable to have rain. The clouds are the evidence of the presence of vapor; they form and disappear at times rapidly. This is the result of the ascending and descending currents.

Within the Tropics, when the Sun is passing over the zenith of any parallel, it has been found that the rainy season prevails. It is explained by the fact that the evaporation at that time is greater, and the atmosphere more saturated; condensation takes place more easily, and the rain is more copious. It is remarkable, that when it is the rainy season in the Tropics, the rains occur only during certain hours of the day, and that the nights are cloudless. The part of the twenty-four hours in which the condensation and precipitation take place, is after the Sun has passed the meridian. Now, under the hypothesis that the vapor is left behind by the rotary motion of the earth, we have a ready explanation of this phenomenon, and some idea may be had of the velocity of the retardation of vapor. Let us suppose the width of the ocean which lies to the eastward of the place where this phenomenon occurs, an arc of the earth's surface, from which the evaporation has arisen; and the time the rains fall, to represent the condensation of the same vapor—the difference between these will give the time of the retardation.

There are several localities within the Tropics where this phenomenon occurs, and where the rain falls for five hours. The width of the

ocean, or the distance to the Coast of Africa, is 2000 miles;—a place on the Coast of South of America would be two hours in passing through this arc. The difference is therefore three hours, and the retardation of the vapor to the west about 400 miles an hour.

As the effect of the Sun decreases, these rains diminish until they cease altogether, when the dry season ensues. The atmosphere being no longer surcharged with vapor, and the land more heated, precipitation does not take place. The vapor, then, which is held suspended, passes onward to the high mountain ranges of the western coast, where it is condensed, and supplies the extensive rivers of South America.

That the vapor is derived from the east, is well established, from the fact that condensation is more evident when the current of air flows from that direction; and it is shown by the prevalence of more copious rains, which take place on the eastern side of mountains and on the west side of seas and lakes. The Caspian Sea is a well-known instance of this. On the east side it is a barren, sandy waste, and rain rarely falls; while on the west it is fertile, with much rain. The rainless districts may also be cited as an evidence that vapor passes over a high plateau, such as the deserts of Gobi, Iran, and Syria, where the temperature is elevated, and the vapor cannot undergo condensation; and that it does not, is proved by the fact that metals of all kinds never oxydate when exposed to the atmosphere; that vast quantities of vapor pass over them, we know, for it is condensed on the Himmalaya mountains, and supplies the large rivers of Asia with their waters. The cause of the rainless and barren district stretching entirely over the African continent, 3000 miles from east to west, by 1000 miles wide, north to south, may also be readily accounted for. The Himmalayan mountains have condensed the vapor flowing over them from the east; the cold and dry air is thence induced onward to the heated areas of the Sahara, having its capacity for moisture greatly increased. On its route it takes up all the moisture which evaporation has left, leaving it perfectly dry and unsusceptible of cultivation. While this continues, it must ever remain a desert.

But it is not my intention to deny that vapor may permeate towards the east; its tendency, as before remarked, is to distribute itself towards the land, and its province is to restore the equilibrium in all directions. This tendency is increased by the wind, particularly when it prevails from the water to the land; its action, however, is very limited. The great precipitation which is observed on many coasts is said to be owing to the moisture brought by the winds. We think this is produced by the descent of the cold currents of air flowing from the upper strata to the warmer surface areas, condensing the vapor,

which has arisen from evaporation over a small extent of ocean near to the coast. The action of the southwest Monsoon, particularly, is often referred to, as transporting the vapors which cause the copious rains on the coasts of India;—but according to the theory, the currents of air seeking this coast are cold, and comparatively dry; but, descending into the vapor plain, to the warmer areas, they produce condensation, and great precipitation follows. The effect may be increased by the height of the Western Ghauts, which rise immediately above the line of coast, and act to retard and condense a portion of the vapor as it is left behind.

It has been thought that winds from certain directions always bring rain; but in places not far distant from each other, they are altogether from opposite quarters which produce this phenomenon. It often happens that the wind from the same direction at one season produces rain, while at another, it is attended with fine weather. This is the case with the northeast winds of Europe, and also with the northeast winds on our own coasts. Every one is familiar with the name of *dry* northeaster. In Europe, at one season, the moisture is condensed on the Ural mountains, lying perpendicular to the flow of vapor, by which the rivers flowing to the north and south from them are supplied;—consequently, none can flow onward to the west. At other times, the vapor passes onward, and is condensed farther to the west, in the centre of Europe. Many instances could be cited to show that this is the case in other places. In Germany, more rain falls than on the coast of France in the same latitude.

It has been often observed that the rains of one wind are different in character from another; this evidently depends upon the rapidity of the condensation: if the air which flows in be but a few degrees cooler, the condensation will be slower, and the precipitation more nearly allied to mist. As the difference in temperature is greater and more sudden, there will be violent rains, and often hail,—and this latter extend in narrow widths over areas, while beyond them, the temperature not falling so low, rain only will take place.

HURRICANE STORMS.

THE fifth postulate which I have laid down, viz.: That currents of air are influenced and disturbed by electricity, will, I think, be readily admitted.

The sudden changes in the atmospheric currents during thunder-storms, water-spouts, and whirlwinds, have been perceived by every one; and none fail to notice that they usually rise against opposing currents of air, which they overcome and entirely divert from their course.

The ordinary storms we consider as the result of the accumulation of heat and vapor over an extended area. The duration and violence depends upon the difference of temperature between the heated area and the denser air, by which it is surrounded. They may have greater or less extent. Observation proves their route to be in the order of progression of the currents of air, as heretofore explained. The hurricane storm is similar, but with the addition of intense electrical action, which produces the local whirl. In other words, the true hurricane storm is to be regarded as an electrical meteor. These we intend to describe.

Although electricity has not been admitted as the great agent which causes the hurricane storms, that carry destruction and leave devastation in their track, yet it is well known to be one of the accompaniments, and its effect afterwards is always seen. It will be my endeavor to show that it is the cause of their origin, and, combined with heat and dynamical forces, sufficient to explain all the phenomena which is witnessed in their local as well as progressive motion.

My purpose is first to treat of the general character of these meteors, endeavor to explain the cause, give their direction, and the areas to which they are confined.

In the first place, these storms, in various parts of the earth's surface, arise from the same causes, and have the same signs and appearances. From the observations of navigators, as well as observers on land, we learn that their characteristics in both hemispheres resemble each other. They are engendered on the sea in the heat of the Tropical regions; while confined to the ocean, they enlarge as they progress; but coming in contact with the land, they often divide, or contract to narrow limits, exhibiting all the marks of intense electrical action within

short distances and confined spaces, as is often witnessed in our own country.

Their origin appears to be nearly on the same parallels, the 10th degree of latitude, in both hemispheres, and they have a whirling motion, but reversed. They are preceded by calms and shifting winds, or light and fitful breezes. Near the centre of action, or within their vortex, a high temperature always prevails. The atmospheric pressure is increased beyond their limits, but diminished within. Their approach is accompanied by a feeling of languor and exhaustion, apparently from a want of elasticity in the air. Their progress is from east to west — their route forms a portion of an ellipse of greater or less diameter, recurving towards the pole of that hemisphere where they originate.

During their formation, the sky becomes overcast, of a deep, leaden color — assumes a lowering aspect — the horizon is surrounded by a dense bank of clouds, from ten to fifteen degrees in altitude, with ragged edges, which tear off in vapors, moving rapidly, not as if borne by any wind, but attracted in various directions. The Sun appears blooded — the clouds tinged with a lurid red, which gradually spreads itself over the whole sea — lightnings dart upwards from these clouds in columns composed of separate rays, of a dull hue, and of long duration. The wind gradually freshens, blowing towards a central point or line. The clouds over-head decrease in height, as though a powerful attraction was operating to depress them, and to confine the approaching storm to the narrowest limits, causing a most appalling apprehension of danger to both man and beast.

The route of these meteors has been traced, from the minimum line of pressure, by very many observations; it is found that it coincides with the central line of maximum heat and vapor. It is known that between the first and last parts of a hurricane, a calm of longer or shorter duration takes place. At times, it appears perfect, and often sudden; at others, more or less accompanied by fitful airs and light breezes from various quarters. The extent of these calms is also remarkable. They have been found to be equal in some cases to one-third the diameter of the storm. During the continuance of the calms, various moanings and loud roarings are heard from the front, which has passed, and from its rear, which is to come.

The last part of the storm, though not of so long duration as the first, is generally considered more violent, and vessels are reported as receiving more damage after the change of wind, which rushes in from an opposite quarter, to restore the equilibrium.

The sudden change of wind from the opposite quarter follows the

calm, which is preceded by sharp flashes of lightning; the temperature falls, the barometer rises, and fair weather ensues, with a pure and wholesome atmosphere. The utmost devastation is apparent on every side, and both animate and inanimate objects show the effect of the action of the electric fluid. During the whole period, the storm is accompanied by excessive and copious falls of rain; that which falls in the latter portion is very much reduced in temperature, and frequently hail is precipitated.

The effect of electricity is seen in the burnt appearance of vegetation,—and in some cases, the crews of vessels have found the effects of lightning upon their persons, although they had not been aware of having seen any.

The first part of the storm which precedes the calm is of much longer duration than the latter part—the rise of the barometer is more rapid than its fall—the change of temperature is equally great. Where these meteors have taken place, their approach, direction, and end exhibit the above characteristics.

To explain these phenomena, it is requisite to have recourse to all the facts that have been established, and the localities where these hurricanes originate — comparing them with each other, to show the directions in which they move, and in what particulars they correspond. From them we derive what we believe to be the true explanation of the phenomena; and where these causes do not exist or prevail, there are no hurricanes, or even storms to disturb the atmosphere; we may then be justified in ascribing to them the hurricanes. The great and predominating causes which we assign for these meteors, are therefore the accumulation of heat and electricity. They are engendered on the sea, where the temperature has attained its maximum. From evaporation, the atmosphere has become surcharged with vapor, and an accumulation of electricity has taken place. At these periods of the year, the winds have in a measure ceased over these areas, or become fickle and uncertain. There is no way in which these accumulations can be carried off. The atmosphere over the sea has become, as it were, a vast reservoir or well-charged battery. The developement of it in many places gives evidence of its existence in vast quantities, and is looked upon as a precursor of these storms. The temperature of the sea has reached its maximum, and the greatest heat of the atmosphere coincides with it, and prevails throughout the route these storms take. The appearances which we have given, as immediately preceding these tempests, also show very clearly powerful electrical action. On their development, a discharge, or successive discharges, either disruptive or convective, take place, and a great repulsion of the atmosphere, by electricity, causes

the displacement of the atmosphere from the surface of the earth to take place, baring it or exposing its surface, creating a large rarefied area, into which the surrounding air rushes with great force, which, coming in contact with the earth's surface, moving from west to east, receives the impulse of its rotary motion, producing a horizontal whirl or volute from right to left in north, and from left to right in south latitude. This whirl continues until friction overcomes its velocity, when it dies away into calm. This is the local effect of the discharge.

The storm continues to advance along the line or route of highest temperature, coinciding with the line of minimum pressure, and progresses in the direction I have named as retrograde on our coast, from the southwest to the northeast, first having originated, as was observed by our celebrated countryman, Franklin, at the south.

As the electric fluid accumulates along the line of heat, it makes successive discharges, either disruptive or convective, producing the same effect as in the first instance, and the same results, more or less violent, according to the intensity of the action of the fluid. Thus the route of the storm follows the line of greatest heat. At each point of accumulation and discharge, the whirls form and continue until their action is exhausted by friction; or, when the equilibrium of temperature is restored, they cease.

Other causes, no doubt, tend to increase the effects which take place, — the expansion of vapor, its condensation, and the evolvement of large quantities of heat, and great precipitation, which always accompany these hurricanes.

The falling of the barometer at the central line is the result of its being the line of maximum heat; the expansion of the column and the upward tendency of the air may increase the effect. Too much attention has been given to the barometrical pressure. This is an effect, not a cause, of the storm; and in future, I trust that the temperature, or thermometrical observations, may claim the attention of those who have the misfortune to encounter them. I am well satisfied that it is a far better guide than the barometer, — and by noting the standing, rising, or falling of the temperature of the air and water, ample time will be allowed to prepare for these hurricanes. In every case where I have found the observations of the thermometer recorded, they show the clearest indications of the approach of a tempest; and by avoiding the line of the greatest heat, you may escape the discharges of electricity and the whirlwinds caused by them.

The part of the great ocean where these meteors occur, lies between the parallels of 10° and 30° north and south of the Equator. They only take place in the northern hemisphere, between America, Europe,

and Africa, and are first developed near to and about the longitude of 50° west, to the eastward of the leeward Islands, whence they sweep along towards the coast of America, in a west and northwest direction as far as the longitude of 75° west, recurving to the northeast in the latitude of 35°, and cease in about the longitude of 60° west, near the 45th parallel north.

In the North Pacific, they begin near the Marianne Islands, in the longitude of 140° east; from thence they extend to the Coast of China in 100° east, turning to the northeast along the east coast of Japan. In a few cases, they have been known to sweep across the Birmah peninsula to Hindostan, where they are dissipated; others are confined to the Bay of Bengal, from the Andaman Islands to the Coast of Coromandel. None of these appear to recurve. Their course is probably short, and, coming in contact with the land, they are soon dispersed.

In the Indian ocean, they originate near the 90th degree of east longitude; thence they pursue a course to the southwest to 40° east, in the latitude of 27 south, where they recurve to the southward and eastward.

In the Pacific ocean, their limits seem to be between 140° west and 165° east. Their extent in latitude is over 25 degrees. Those that have been experienced in the southern Pacific, recurve, but in what direction the observations have not yet been sufficiently numerous to establish.

In examining the route which these meteors take, it will be found that they extend along the line of the highest temperature of both air and ocean, at the season when they take place. When they recurve, they follow the warm currents of the ocean or the highest temperature of the atmosphere.

The action and effect of these storms are well understood by the inhabitants of the countries which are subject to them. They find it necessary to secure their doors and windows from being burst open by the expansion of the air within, and barricade them, to prevent it. This tends to prove that within the vortex a partial vacuum is produced. In some of the hurricanes which have taken place in our own country, we find every indication that the same effects take place. The falling of trees show most conclusively intense electrical action, with which the the wind has no connexion.

SAILING DIRECTIONS.

SAILING DIRECTIONS.

CLOSELY connected with the "Theory of the Winds" is the practical use which results from it to navigation. I therefore deem it proper to add these sailing directions for a voyage of circumnavigation, with a short description of the principal ports visited by the Exploring Expedition.

For a full detail of the valuable labors connected with the Hydrography of the Exploring Expedition, I must refer to the volume already mentioned, which, for the reasons stated in the Introduction, cannot reach the public until Congress orders another and larger edition.

The one subject will tend to illustrate the other, whilst the annexed map will show the direction and extent of the winds, and point out the routes which are most advantageous for our commercial marine to follow.

At this day, it may seem superfluous, or be deemed a work of supererogation, to make any remarks on the Passage across the Atlantic, a sea so much frequented. There is no ocean where so many vigias are laid down on the charts, and of which the accounts are so contradictory, or in which there appears to be so great a necessity for a thorough examination, to set at rest these doubtful dangers; yet, strange as it may appear, nautical men seem to be averse to publishing any observations that may enlighten those who may pass after them, —so that all navigators are left to derive knowledge from their own oftentimes dear-bought experience.

In these Sailing Directions I shall, as I have done in the Hydrography, follow the order of the cruising of the Expedition, from port to port, around the world.

CAPES OF VIRGINIA TO THE CAPE DE VERDE ISLANDS.

From the 18th of August to the 7th of October, 1838.

The passage first in order is that from the Capes of Virginia to the Cape de Verde Islands. It was remarkable, as illustrating the length of passage caused by a difference of routes across the Atlantic.

It was my intention to pass into the Gulf Stream, and continue in it as long as it lay in my power, but the winds not permitting us to pursue that course, we were compelled to pass outside of it. I feel satisfied that it would have expedited our passage to Madeira, had we

kept within it, but the temptation of steering within a few points of our course, which the wind permitted, prevailed, and we continued our route without it, though nearly parallel to its direction, receiving but little aid from it, and experiencing variable currents and light winds from the northward and westward; but at the same time avoiding exposure to the heavy August gales, which were to be expected, and from the experience of many, are believed to be much more severely felt within its limits, and are extremely dangerous from the effect of the current, which renders the sea higher and shorter.

The Relief parted company when four days out, with orders to make the best of her way to the Cape de Verde Islands. Lieutenant-Commander Long, her commander, chose a direct route across the Atlantic, for the Cape de Verdes, between the parallels of 32° and 34° north, and continued it for 37 days, until he reached the longitude of 37° west. During all this time they were seldom able to steer their course, and were constantly annoyed by light easterly winds, with opposing currents, until within a few days' sail of the port, reaching it after a passage of 60 days.

The Relief was not to be classed among fast sailers, but it is believed would bear a fair comparison with ordinary merchant vessels that carry a large cargo. At any other season, it is probable she would have made better time; but when the Sun is approaching the northern Tropic, there is little doubt that the result must be the same, by pursuing a similar route; light and variable winds will always then be found. As far as this passage serves, it proves that they generally prevail from the east instead of the western quarter.

The route which I took with the squadron was between the 37th and 38th parallels, to the Azores, some 200 miles to the northward of that of the Relief. Here we find a totally different state of things. The wind was fair 16 days out of the 28, and we only encountered adverse winds during 6 days; and I am under the impression that, had our passage been made on a more northern parallel, we should have shortened it by having more wind and deriving greater assistance from the Gulf Stream; indeed, as a proof of it, the Peacock, after parting company, kept about a degree to the northward of the Vincennes' track, and reached the Azores two days before us, but was detained longer in consequence of passing between the islands of that group.

On this passage, the position assigned St. Anne's Shoal, as well as a vigia in latitude 38° 8′ north, long. 34° 3′ west, was visited, and no appearance of either found. It is my belief that many of these shoals and vigias, which have obtained a place on our charts, result from encountering large trees in boisterous and thick weather, or during the

night. It would appear likely that they should be met with hereabouts, having been brought by the currents or Gulf Stream, and for a time remain floating in this part of the ocean. In this longitude (42° west), we encountered many pieces of drift-wood, as well as large trees, which were of a deceptive appearance until closely approached.

The course to be pursued in passing the Azores bound to the eastward, is to give them a wide berth to the northward or southward; the former in the winter months, the latter in the summer months, when the winds incline mostly from those quarters, by which a steady wind will be secured in the neighborhood of these islands, when it is often interrupted and variable nearer them.

The position of the Tulloch Reef was passed near to, reported in the neighborhood of the Formigas Rocks as long ago as 1808, and said to have been seen several times since. In 1829, it was diligently sought for by H. M. S. Ariadne, expressly sent for that purpose, without success. We also have to report its non-existence.

The approach to Madeira is generally shaped for the purpose of doubling its eastern end, and thus taking advantage of the prevailing winds to reach the roadstead of Funchal with the least delay. There are seasons when the winds permit an approach from the westward: this being the case at the time of our visit, I took advantage of it, in order to save time, and by standing close along the southern shore of the island, favored with a gentle breeze from the southwest, we were wafted by sunset to our anchorage in the roadstead. Ordinarily this is not an advisable course to pursue, as a large vessel may be sometimes becalmed, or meet with baffling and light airs, in passing under the high land, and be unable to reach an anchorage. It is better to approach from the eastward when the northeast winds prevail. During June, July, and August, a day and upwards may be saved in reaching the port. Captain Hudson, in the Peacock, took the eastern route, anticipating a leading wind to the anchorage: on the north side of the island he found the wind northwest, and as he proceeded round the east end, it became southwest, which caused him to stand well over towards the Deserters, where the wind was baffling and squally, with a current setting to the south and east.

It may be as well here to notice that the best anchorage in the roadstead is limited to the range of the Loo Rock with the Castle on the Hill; you then avoid the declivity of the bank to the eastward, which deepens suddenly, and have a good depth of water to anchor in, from a half to one mile out. Not having been aware of this, I anchored further to the eastward than this range, and was obliged to change to a place of more safety the next morning. I mention this circumstance

in order that others, on their first visit to this port, may not fall into a like error. During our stay, the winds were light and variable, generally from the southward and westward.

At Madeira it is scarcely requisite to inform the navigator that all kinds of provisions may be had to recruit, but it is a bad place to effect repairs in.

From Madeira we steered to the southward, with the intention of passing over the positions of several reported shoals. The winds, in our passage from Madeira to the Cape de Verdes, were light, though favorable. They were found to prevail in veins, generally springing up fresh for a few hours, and then dying away to nearly calm. There appears to me great necessity for taking advantage of all these spirts or cat's-paws; the greatest attention is required in keeping the ship on her course, to secure all the progress possible, as a mile, or even a smaller distance, in position, may make a great difference in time when a favorable breeze is taken, and the voyage is accelerated or retarded accordingly.

The winds on this route, from latitude 29° to 27°, are no doubt somewhat influenced by the proximity of the Canary Islands, and the approach to the Trade Winds. I am satisfied that attention to the trimming of the sails and sailing of the vessel, whilst passing through these latitudes, will greatly expedite a voyage. We did not obtain the Trades until we had reached the latitude of 26° north.

We encountered on this passage, between latitude 24° 30′ and 18° 25′ north, on the meridian of 20° 40′ west, an extent of 360 miles of water as green as that of but 50 fathoms in depth. In passing through it, we repeatedly sounded in from 150 to 300 fathoms, without obtaining bottom.

The width of this discolored water I have ascertained to be about 150 miles, on the parallel of latitude 21° north. In passing into it, the temperature fell 2° of Fahrenheit, and rose the same amount on passing out. The line of demarcation was very well defined, the sea on either side being of a deep blue. It was noticed in the voyage of Frazer, in 1712, but, considering the great number of navigators who have since traversed that part of the ocean, it does not seem to have been often observed. There seems to be an impression by those who have noticed it, that soundings could be had, but the lead has been often tried, as was the case with us, to various depths without success. Many have imputed the discoloration to animalculæ, but I am confident that this was not the case at the time we passed through it, for careful examination failed to discover any in water taken from the surface as well as that from a depth of fifty fathoms; and I would also urge

against its being the effect of animalculæ, the long continuance of it in the same place. Whether it is the reflection of the bottom, as some suppose, or a peculiarity of the surface waters, emanating from the rivers of Africa, I leave for others to decide; it is a phenomenon well worthy of investigation. While in it we saw no phosphorescence of the water, but on passing out, it was very evident. To determine its actual limits, both in breadth and width, is a work of no great difficulty, and if observations were repeated, in a few years the question would be settled as to its being permanent.

In the Pacific as well as Atlantic ocean, there are many places of discolored waters, betokening banks of large extent, which have served useful purposes in navigation. The discolored water to the windward of Barbadoes and that of the false Brazil Bank, are well-known examples.

The deep sea temperature at the depth of 350 fathoms, was 23° less than that of the surface.

The reputed shoals, on which it is said the Maria and Bon Felix struck, are on this route; the former is said to be in latitude 19° 45′ north, longitude 20° 50′ west, and the latter in latitude 19° 20′ north, longitude 20° 37′ west. Both of these situations were passed over by the squadron in open order, so as to cover a large area. The examinations of the localities fully satisfied us that no such shoals exist where they are laid down. It is to be hoped that this evidence will have the effect to cause the erasure of these supposed dangers from the charts.

On this passage we found the current tending to the northward and eastward, from one-half to five-eighths of a knot per hour, but there was none most of the time. Many navigators give it as setting to the southwest. The set of the ship by current in the whole passage was found to be north 57° east, 42 miles in 13 days.

The Bonetta Rocks, in latitude 16° 32′ north, longitude 20° 57′ west, said to lie to the eastward of Bonavista, and nearly in our track, I determined to make search for. Although the account given in Purdy's Atlantic Memoirs appeared so well authenticated, and the failure to find them after so diligent a search as that made by H. B. M. ship Leven, Captain Bartholomew, left but little hope of our being more successful, yet I considered the sweeping over the locality with the squadron would be still more satisfactory; we therefore passed over this locality, as well as an area of ocean of from 40 to 50 miles in extent in the neighborhood, with the lead continually going to the depth of from 60 to 70 fathoms, and good look-outs both below and aloft, the sea being quite smooth; we also, after having passed over the position assigned them, continued to steer on their reported bearing towards

the island of Bonavista, but saw nothing of them. It appears that in the year 1841, the British ship Charlotte was wrecked on a shoal which was reported in latitude 16° 17′ north, longitude 22° 21′ west, the nearest we approached this position was eighty-two miles, on a bearing of north 79° west. I am still inclined to doubt the accuracy of this position, as it appears to have been passed over by H. B. M. ship Leven in her search. Should the rocks be hereafter seen, I have little doubt that their true position will correspond to that of the Hartwell Reef, on which a ship of that name, and the Madelaine, were both lost.

In this neighborhood we encountered many tide rips, and found the current, on trial, to set northeast by north three-quarters of a mile per hour.

Formerly it was deemed equally feasible as well as more advantageous to pass to the eastward of the Cape de Verdes, to be enabled to cross the Equator on a more eastern meridian. Vessels now seldom pursue this route, unless they have similar intentions with ourselves, viz., to touch at St. Jago.

Experience has proved that the best course for vessels to take that are bound across the line, is to pass some distance to the westward of San Antonio; some, however, still prefer sighting this island, to ascertain that the rates of their chronometers have not altered.

Before leaving the Cape de Verdes, and as somewhat connected with the interests of navigators, I may call attention to the remarkable dry haze that frequently envelopes these islands, which renders all objects indistinct, and at times entirely obscures the horizon, so as to make it impossible to get observations with accuracy. Our observations place the fort at Porto Praya in latitude 14° 53′ 45″ north, longitude 23° 30′ 55″ west.

The supplies for ships at Porto Praya are not to be depended upon, if required in a short time; indeed, they are, at times, very difficult to be had, the cultivation of late years having been much neglected, in consequence of the few vessels visiting it, and the small demand in comparison to what it was formerly.

The magnetic variations decreased with regularity from Madeira to the Cape de Verdes, viz., from 24° to 17° westwardly.

FROM THE CAPE DE VERDES TO RIO DE JANEIRO.

From October 8th to November 20th, 1838.

On leaving Porto Praya, my intention was to pass over the position of several shoals, which were embraced in my orders, and which lie on the route of ships, in the part of the ocean we were to traverse. I was

therefore, not particularly anxious to cross the Equator on any particular meridian, but to be governed more by the opportunities I might have of making our search as effectual as possible without losing too much time.

We lost the northeast Trade Winds, with the wind at north, the day after we left Porto Praya, when we were in 12° 24′ north latitude, and 23° 45′ west longitude, and afterwards experienced squalls, with much rain and lightning. On the 23d of October, the Relief lost the Trades in 11° north, and on the meridian of 22° west. The Danish brig Lion, which vessel we spoke, had lost the southeast Trades in 6° 30′ north, and the ship Crusader likewise informed us that she had lost the Trades in 7° 30′ north, both having crossed the line between 22° and 27° west longitude.

Patty's Overfalls was the first supposed danger we steered for, in longitude 24° 30′ west, and latitude 11° 02′ 18″ north. On the 11th of October, we reached this position, and were in its neighborhood for forty-eight hours. Various tide rips were encountered, trending east and west, but no current was found to exist, either by our observations, or by the trial with the current log; so that I feel satisfied that Patty's Overfalls does not proceed from reefs or shoals. At other seasons there may be an appearance of broken water, but there are no dangers existing.

It was with some difficulty we reached the position of Warley's Shoal, in latitude 5° 04′ north, and longitude 21° 35′ west. We examined this locality thoroughly, but without success. From the manner of our search, I am well satisfied it does not exist in the position assigned it.

The westerly wind which we found in this latitude enabled us to run to the eastward as far as longitude 13° 53′ west, to look for the French Shoal. The positions assigned it by both French and English Hydrographers were passed over, the first in latitude 4° 05′ north, longitude 20° 35′ west, and the second in latitude 4° 15′ north, longitude 19° 20′ west.

When we had reached 5° north latitude, we passed out of the sultry and damp weather that we had been subjected to for twenty days. Since we had lost the northeast Trades, in 12° north latitude, we had comparatively little rain, and the expectation of filling our water-casks was not realized. I mention this circumstance, as I find, from investigation, that there appears to be less rain in October and November than other months in the year; therefore, those who pass at one season, and obtain a supply, may be disappointed in another. About the equinoxes (particularly the vernal), more rain falls than at other times. The

quantity of rain that fell during this passage, was only 6·15 inches, and the greatest fall in 24 hours was 1·95.

As we approached the southeast Trades we had a long swell from the south southeast, which gradually grew more perceptible until we reached them. We crossed the Equator in 17° west, and sounded for the Triton Bank under the longitude of 17° 46′ west, and latitude 0° 32′ south, keeping the lead constantly going, but no appearances of a shoal, either in the color of the water, tide rips, or soundings, were perceptible. The current setting to the northward had influenced us very considerably for the last few days before reaching the Equator.

In passing through this space between the north and south Trades, we observed the upper strata of clouds passing rapidly from the eastward.

From the number of rips encountered, and the variation of the temperature of the water from 3° to 5° between them, I suspected that a current of some magnitude existed, but after making frequent trials, it was found of very little strength and running to the east northeast.

The winds, until we reached the Equator, prevailed from south southwest to south southeast, generally light, inclining to calm; those experienced by the Relief were very similar, 15 days later.

The set by current of the Squadron from Porto Praya to the line, in 24 days, was north 25° east, 132 miles. The Peacock experienced it north 56° east, 144 miles in 23 days, and the Relief north 48° east, 203 miles in 25 days.

A variety of opinions have always been held on the subject of the best meridian on which to cross the Equator. I propose to say a few words upon it, having found it almost impossible to arrive, after examining all of them, at any satisfactory result. In my opinion, the season of the year ought alone to be the guide; that which controls more than anything else, being the Monsoons of the coast of Brazil. During the prevalence of the southerly Monsoon, it is extremely disadvantageous to cross the line too far to the westward, for, after being so fortunate as to pass Cape St. Roque, the prevailing winds may be found to the southeast, and sometimes as far as south, thereby driving a vessel upon the coast, and subjecting her to tack to the eastward again, and consequently to a very long and tedious passage. On the other hand, during the northerly Monsoon, a vessel pursuing a more westerly route would meet with no detention, but, on the contrary, having the wind to the northward and eastward, at times as far as north northeast, she would be enabled to make rapid progress, with a free wind on a line parallel with the coast. It is thus evident that the Equator may be passed well to the westward, if the Sun is advancing to the southward,

but, on the contrary, it is always safer to navigate well to the eastward during the advance of the Sun to northern declination. These directions are intended for all kinds of vessels, as well the slow as the fast, and notwithstanding the latter may pass with less difficulty, yet it is beyond a question that even with them a much quicker passage would be the result of taking the most favorable route. Another reason is to be found in the necessity there seems to be to avoid entering the great Equatorial stream before reaching the Equator. We found it cutting the Equator about the meridian of 18° west, at an angle of fifty degrees; and although our experience may not determine its actual northern boundaries at all times, yet it is probable it does not vary very much from that here given; consequently, vessels passing the Equator in a more western longitude, would enter it before reaching the Equator, and be subject to its influence much sooner. By taking a course to the eastward, it would be entered later; but it is to be considered whether the opposing northern current, in a more eastern longitude, is not as disadvantageous. On the other hand, by crossing at the meridian of 18° west, it is evident that the Equatorial stream would not be encountered until the winds from the southeast had become so well established, that its influence would be less felt, and it would have but comparatively little effect on a vessel, until she had the means of quickly passing beyond its influence, and therefore be subject to it, the shortest possible time; on this account, I am decidedly of opinion that, taking the winds and currents into consideration, the nearer a vessel, bound to the south across the Equator, can cut the meridian of 18° west, the better at all seasons of the year, though during the favorable Monsoon, I would myself try, and even recommend, a more western meridian.

Much has been said about "*Great Circle Sailing*," and it has been recommended particularly on this route. Although I do not wish to dispel the illusion, or to detract from the merits of the officers who claim the origin of "Great Circle Sailing," I cannot but do justice to the prior right of Mr. John Garnett, a distinguished mathematician, of New Brunswick, New Jersey, whose devotion to nautical science was well known, and who published the first edition of the American Nautical Almanac in 1815, and a set of highly useful nautical tables as early as 1816, and who, about the same time, drew up and published a chart, showing the projection of the "Great Circle Sailing," under the title of "Loxodromic Curve," copies of which I had the honor of presenting to the Honorable Secretary of the Navy from the author, on my first entrance into the navy. By claiming a prior right for a distinguished mathematician, a friend and associate of Adrain, Vateck, Fulton, and other distinguished mathematicians and mechanicians of

our country, I do not mean to detract from the laudable exertions of any one, but I would call attention to the fact, that there are few parts of any ocean in which the loxodromic curve can or ought to be pursued; and although the route from the United States to the Brazils is one of those on which it is strongly recommended, I think there are sufficient reasons why vessels should not attempt it. Many have failed entirely; others have but partially succeeded,—whilst others, again, have made quick passages. Those voyages which I have examined, have derived all their advantages from gaining the line at the most favorable time to take the northeast Monsoon of the Coast of Brazil, which is fallen in with sometimes as far as 5° to the north of the Equator, and at times the wind veers as far to the northward as north, thus giving vessels, though close to the Coast of Brazil, a favorable opportunity to make the passage the whole distance almost on a loxodromic curve, or the shortest distance between two points,—evidently the most desirable to be sought for, or taken, if possible; yet there are few routes across the ocean where the winds will permit its being taken to advantage at all seasons, except within the Trades: those passed, the variables succeed, and change so rapidly, that it is next to impossible to pursue, for any length of time, a course on any loxodromic curve.

From the Equator to 3° south, the set by the Equatorial stream was south 69° west, 75 miles, while from latitude 3° south, longitude 20° west, to latitude 13° south, longitude 30° west, its set was north 80° west, 100 miles; thence to the latitude of Cape Frio it was to the southward and westward. The amount of current between the Equator and Rio was north 82° west, 300 miles, and that experienced from Porto Praya was north 56° west, 288 miles. The greatest set we experienced between latitude 10° north and 13° south, was on the meridian of 26° 30′ west, 30 miles a day, nearly west.

The position of Bouvet's Sandy Isle was passed over, but nothing whatever was seen of it. As it was my intention to examine the position of Krusenstern's Volcano, I limited the search under the Equator to the twentieth degree of west longitude, as I was apprehensive the Equatorial current might render it impossible to reach its assigned position in longitude 20° 41′ west, and latitude 2° 53′ south. The Squadron passed over the locality three times in different directions, but saw no indications of a shoal.

We were 25 days in reaching the Equator, and 20 days from the Equator to Rio de Janeiro.

Very great differences occur in estimating the latitude to which the southeast and northeast Trades extend, arising no doubt from sailing to or from them; in both cases great allowance is to be made for the

want of accurate observation and disappointment often experienced in losing or meeting them. As respects my own experience on this voyage, and from information obtained, navigators give the latitude where they lost the southeast Trades, too far to the north, and in sailing in an opposite direction, too far to the south; therefore, we find several degrees of difference assigned the Trades at the same period when they could not have altered to any extent. The condensed table which Horsburgh gives as the result of his examination of 238 voyages shows this fact. Although many of his sailing directions have been superseded, yet the debt that all seamen owe to this great navigator is not to be measured. Few men have done so much for the commerce of the world, and his industry in obtaining nautical information and compiling sailing directions, has been the cause of preserving many lives, and a vast amount of property.

In crossing the space between the northeast and southeast Trades, the changes of wind are at times sudden, and require constant attention; sometimes severe and rapidly shifting squalls are experienced: one of them happened to us in latitude 9° 30′ north. The squadron was sailing in close order, with a fresh breeze from the southeast, when the vessels were taken suddenly aback by a squall from the southwest; in a few minutes we had the wind from different quarters, so that it required, during the time it lasted, good management of the vessels to avoid running into each other.

The approach to Cape Frio is safe at all times, the light-house now established affording all necessary facilities to the navigator to advance without fear or apprehension at night. When the light cannot be seen from haze or thick weather, the soundings, as well as a fall in the temperature of the water, will indicate a proximity to the land. The soundings extend some 25 miles, and are of ooze and shells. The light-house on Cape Frio we found to be 1285 feet above the level of the sea, placed on the highest peak of the island, and is often enveloped in mists and clouds. Its position appears to have been chosen that it might be seen from as many points as possible. It is a revolving light, and can be seen distinctly from 30 to 35 miles in clear weather. As this is a point which is always made by our ships, and from whence their departure is usually measured, it was deemed important that its correct position should be ascertained: this was effected by connecting it with the observatory on Enxados Island, the position of which had been determined by a series of moon-culminating stars. Sound and chronometers were employed as the most convenient and expeditious mode to measure the meridian difference: the result placed the light-house on Cape Frio in longitude 42° 00′ 13″ 87‴ west.

It has been generally supposed that it was necessary for vessels to await a favorable wind to enter and depart from Rio Janeiro, but this is a mistake; there is no difficulty whatever in vessels departing or entering, at any hour and with any wind and favorable tide: the best time, however, to enter is during the day, when the sea-breeze is fresh: it ordinarily dies away at sunset, and then remains calm until an early hour in the morning, when a gentle land-breeze prevails until about 9 o'clock.

So safe and free from danger is this harbor, that pilots are unnecessary, but it is requisite to pay attention to the tides, which at times run with great velocity. There are times, too, when squalls prevail, from the southwest to northwest, which sometimes blow with violence; and I have been informed that a heavy sea has been experienced at the anchorage in the harbor, so much so, as to prevent any landing at the Great Quay, and rendering it necessary for boats to seek the upper or mercantile harbor to land, where it is practicable at all times. Vessels lie at anchor, and lighters are employed to land all goods, thereby causing a detention, as well as expense, in discharging the cargoes.

The situation of the upper harbor is well adapted for the erection of wharves, and they might be constructed with little expense, and would be entirely protected from the influence of the winds and sea by the small islands of Enxados and Cobra.

The tide in the harbor of Rio ebbs and flows $4\frac{1}{2}$ feet, and it is high water at 2 15m P. M., full and change. A tide-staff was kept during the time of our stay, and marked hourly, night and day. The ebb often runs very nearly the whole day, and is always represented as much stronger than the flood.

Vessels, after leaving the harbor of Rio, would do well to follow the example of the coasters, and stand down along the northern shore towards Cape Frio, for they would thereby not only preserve the land-breeze, but also be assisted by the counter current which sets along the shore, and save much of the time that is frequently lost by standing off to the southward and eastward, when not only contrary winds are met with, but frequently calms of some duration. The coast is free from dangers, and a vessel of any size may approach it within a short distance. The light on Raza Island we found to be a brilliant revolving light, showing alternately a deep-red and white light.

The port regulations of Rio are somewhat unfavorable to trade, and the number of holidays interfere with the desirable despatch in the loading and unloading of vessels; but as the commerce of this region

is rapidly on the increase, it is believed that a better system will ultimately prevail.

Every kind of supplies may be had here, and generally at reasonable prices.

FROM RIO DE JANEIRO TO THE RIO NEGRO.

Between the 6th and 25th of January, 1838.

On the 6th of January, 1839, we got under way and dropped down the bay, but the breeze in a short time left us, and we were obliged to drop our anchor until the sea-breeze set in, which we were favored with at about 10 o'clock, when we made sail and beat out of the harbor with the last of the ebb tide. In the afternoon we anchored outside the bar, in 20 fathoms, white sand, owing to the breeze failing, as well as to await the return of one of the tenders, which I had despatched back to Rio on business: the time was, however, usefully employed in measuring the altitude of the Sugar Loaf. It continued calm until the next afternoon, when the sea-breeze was so light, that I determined to await the land-breeze, which came off at an early hour in the night, when we made sail, and stood to the southward. On the 9th, we had heavy showers, with lightning, but no thunder, succeeded by a southeasterly wind, and a reduction of temperature, which gave us great relief, as we had been suffering from the heat for the last eight months. On the 11th, when we had reached the latitude of 30° south, the air had assumed a very perceptible change in respect to its hygrometric state, being now much drier, and giving a feeling of more elasticity than we had experienced for some months. We had fine weather, with the wind from the northward and eastward, increasing towards evening. On the 15th, we had reached the latitude of 34° south, and longitude 51° west, just to the northward of the Rio La Plata. The current previous to this time, had been experienced to the southward and westward, and as we were now on soundings in 80 fathoms of ooze, the current was tried by anchoring a boat, and was found to be setting north by west 6 fathoms.

On the 18th January, the twelfth day from Rio, in latitude 37° south, longitude 52° 40′ west, we passed into the discolored water of the Rio de la Plata. The line of demarcation on entering it was very distinct, and its temperature 4° less than the surrounding ocean. We continued in it until after passing to the southward of the latitude of the La Plata, being about 80 miles in width. To the northward of latitude 40° we again struck soundings in 55 fathoms, which proved to be sand. From this it is probable that the ooze deposit of the river has spread over an area of great extent north and south.

The great fall of temperature, both in the water and air, which we experienced in latitude 40° south (some ten degrees), with thick fog, led me strongly to believe that we were in the immediate vicinity of icebergs, which have often been seen in this latitude, and longitude 50° west. Commodore Wadsworth, in the Vincennes, on a former cruise, encountered them in latitude 39°, and longitude 54°, and had great difficulty in escaping from them; on this point navigators should be cautious at this season of the year (January). The best course to pursue, in order to avoid the ice, I am satisfied, is to keep near the Patagonian coast. Ice has been seen in great quantities to the east of the Falkland Islands, and although commonly in the form of field ice, yet it is dangerous, requiring the greatest care on the part of the navigator. By taking the open sea to the eastward, instead of getting out of it, the probability is it would be encountered in much greater quantities. As far as my inquiries went, I satisfied myself that when met with on the edge of soundings, it will be found to interrupt the navigation more seriously to the eastward than along the coast.

Our run towards the Rio Negro was attended with fine weather, with the winds from the east round by north to the west; after reaching the parallel on which the Ariel Rocks were believed to exist, and to the eastward of the longitude, we sailed two degrees to the west, but saw nothing of them, and from our search, and that of others, we feel satisfied that they have no existence. The position in which they were supposed to lie was in latitude 40° south, longitude 57° 33′ west.

As we approached the coast, we found the soundings extremely regular, varying about a fathom for every three miles. The coast at the mouth of the Rio Negro presents a low line of sand-hills. To the south of the river is a bluff 100 feet in height, of tertiary limestone, regularly stratified; to the north of Point de Maine, there is a remarkable sand-hill, called the Barrancas; and beyond are seen others, which terminate in extensive pampas.

We dropped anchor off the Rio Negro on the eighteenth day from Rio de Janeiro.

The Rio Negro is barred; and from the examinations we made, and the reports of the pilots, it is a shifting bar. In endeavoring to enter the former channel, without pilots, with the tenders, we grounded on a sand-bar that had recently formed, rendering it no longer practicable for the entrance of vessels. A vessel drawing more than 10 feet water cannot safely enter the Rio Negro. The best position to anchor in the roadstead is with the flag-staff on Point de Maine, north 65° west, in about 9 or 10 fathoms water, within a mile and a half of the breakers, which extend in a northeast and southwest direction.

Pilots are usually found here, but in case they should not come off immediately, it is better to wait for them than to attempt to follow the directions for entering, which, from the shifting of the sands, are not to be relied upon after a flood or freshet. At the time of our visit, two poles were placed on Point de Maine, one on the hill, and another near the beach; the first had several pieces nailed across it, that served for the purpose of ascending, for a look-out; these poles, kept in range, were intended as guides to lead a vessel in the deepest water over the bar, and until within half a cable's length of the point, which must then be turned short round to pass into the river. It is probable that the same marks will be retained, and changed as may be required. It would be well for boats intending to enter, to keep the ranges on, as it will keep them clear of the breakers. The course by compass in was northwest ¾ west. At high tide, the water on the bar will be found to be 23 feet deep; the passage by a vessel never should be attempted but at high water. The rise of the tide, at full and change, is 11 feet, and the current at the mouth of the river runs 5 knots; at the anchorage in the roadstead it was 2 knots. The tide in the river usually runs ebb 10 hours, and the flood 2 hours; but during the freshets it runs ebb the whole time. Large quantities of sand and mud are brought down, and on meeting with the ocean water, is deposited, forming the extensive bars.

The roadstead may be considered at all times dangerous, but particularly so during the winter months. The holding-ground, composed of coarse sand, gravel, and shells, with clay, is good. From May till October, southeast gales are frequent, which blow directly on shore, accompanied by a heavy sea. There is no great difficulty in getting off shore, provided advantage be taken of the flood tide, which sets to the windward, casting on the starboard tack. They are preceded by a heavy swell and thick weather, and are indicated by the barometer, which we found exceedingly sensitive to change to the south of 30° latitude.

The tide off the Rio Negro sets strong (the flood) to the southwest 5½, the ebb to the northeast 6½ hours. This is opposite to what Capt. King gives it in his Patagonia directions, between Cape Blanco and Cape Virgins.

During the prevalence of northerly and westerly winds the weather is fine and the sea smooth.

Water may be obtained about a mile within Point de Maine, and after settling, is considered wholesome. Supplies may also be had, but only in limited quantities, the lack of industry of the inhabitants being

the cause of the scarcity, for the soil is capable of producing vegetables and fruit in abundance.

Vessels intending to visit this part of the coast would do well to seek the fine harbor of San Antonio, at the head of the bay of San Mathias, where supplies, I was informed, can be as readily obtained as at the Rio Negro. It is but about thirty miles from the town of Paula del Carmen. The charge on vessels in these ports is half a rial per ton; whale ships are admitted free for less than twenty days.

RIO NEGRO TOWARDS ORANGE HARBOR, TIERRA DEL FUEGO.

From the 3d February to 17th February, 1839.

We made this passage in 13 days; it was considered a favorable one. Our route was farther off the coast than I desired, in consequence of experiencing for the first two days fresh gales from the southwest, accompanied with a heavy sea, which drove us off; it would have been but lost time to have regained the coast, and followed it down on soundings. One of the Squadron, the Relief, sighted the coast frequently on her passage from Rio de Janeiro to Orange Harbor, stopping for two days at Good Success Bay; she made the passage in 42 days, the same length of time taken by the Squadron, although we passed eight days off Rio Negro. On the seventh day, we reached the Straits of Le Maire, previous to which we passed near to, but a little to the westward of the place assigned L'Aigle Rock: its position is given as latitude 51° 50′ south, longitude 64° 45′ west, which had been searched for previously by others without success.

The weather we met with before entering the Straits of Le Maire was boisterous, but not more so than we anticipated or had reason to expect. The winds prevailed mostly from the northward; those from the southward were dry and cold; the northerly ones brought damp and rainy weather; they change to the southward and westward by the north and west; the precursor of this change is usually a heavy bank of cumuli in that quarter. The barometer was an indicator of bad weather, but I here observed, for the first time, that the wind did not begin to blow until the mercury began to rise; any change from the northward to the southward was attended by a fall in temperature of several degrees.

The winds on the east coast of South America for the most part prevail from the northward and eastward, or the southward and westward, and very seldom are found to remain long in the southeast; but the severest gales that are felt in these latitudes are from that quarter.

Off the coast, near Watchman's Cape, lie the Bellaco Rocks. There

are two distinct rocks, bearing from each other south 17° east (true). The northernmost was seen by Captain Stokes, in 1828; he placed it in latitude 48° 30′ 50″ south, and longitude 66° 09′ 25″ west. The Relief made it in latitude 48° 30′ south, and longitude 66° 07′ 11″ west. This I have named Stokes's Bellaco, while that which lies in latitude 48° 38′ 44″ south, longitude 66° 03′ 53″ west, about 10 miles distant, I have called Long's Bellaco. The latter was discovered by Lieutenant-Commander Long, of the Relief, who appears to be the first navigator who saw and verified both rocks. The latter is believed to be the true Bellaco of Nodales.

Watchman's Cape should be cautiously approached, and if not required to be sighted, had better be avoided, in consequence of the strong currents that prevail in its neighborhood.

To pass through the Straits of Le Maire, I would always recommend making the land to the westward with the ebb tide, but Middle Cape on Staten Land, with the flood; the reason is, that the ebb sets towards the Staten land shore, and the flood to the Tierra del Fuego side.

Our passage through the Straits of Le Maire was effected in a few hours, although we were not particularly favored with good weather. We entered the Strait with a fair wind and all sail set, but were reduced before we left it to close-reefed top-sails, in consequence of the squalls that came rushing out of the ravines of Tierra del Fuego, as we passed them. We made the land off Cape St. Diego in the morning about 8 o'clock, and by 3 o'clock we had passed through, and had Cape Good Success bearing to the northward.

Some navigators have thought proper to caution others against attempting this passage. I have carefully examined the supposed difficulties, and think they are more imaginary than real. The Strait is 12 miles wide, has no hidden dangers, and its coasts are high, and may be closely approached by any class of vessels without fear; there is, in fact, nothing to contend with but the tide, which runs occasionally with great velocity, and with a contrary wind produces a short, and sometimes a heavy sea. We were exposed, in the Porpoise, to a strong gale of wind, and passed through what has been reported as "The Dangerous Race," off both Middle Cape, and that of St. Anthony, on Staten Land, without difficulty.

It is high water, at the full and change, off Cape St. Diego, at 4 o'clock, P. M. Here again we encountered the "Race," and although we were knocked about with some force while in it, yet we did not apprehend or perceive any danger. I would recommend keeping near the middle of the Strait, as the squalls or "*williwaws*" do not blow so

furiously as near the high land, nor will vessels be subjected to calms as on the western side. Good Success Bay offers a stopping-place for vessels in case the weather should prove bad. The anchorage is good during gales from the southwest, but when it blows from the southeast, the sea sets in, and it becomes rough and quite dangerous. The Porpoise and Relief stopped here: the former, on the wind veering to the southeast, was obliged to slip her cable and leave the anchorage, owing to the heavy sea. As at Rio Negro, it is necessary to slip when the windward tide is flowing strong.

The survey of this bay by the Beagle we found correct, but the directions are not quite so plain as is desirable. When sailing along the coast from the south, on which side it is generally approached, there is little appearance of a bay. The "Broad road" of Cook, though given as the direction for it, is not sufficient. The first guide is the "Sail rocks:" they lie 5 miles southwest by south from Good Success Bay. The two jagged, rocky heights, resembling a cock's comb, will present themselves when the bay is open to view. The best place to anchor in, is in 10 fathoms, sand and shells, a short distance outside the line of kelp, the "Cock's comb" bearing southwest by west, — a berth convenient for procuring both wood and water. Scurvy-grass and wild celery, with berries, may be obtained in quantities.

The currents from Rio de Janeiro to the Rio Negro, we found south 39° 30′ west, 167 miles. From Rio Negro to the Straits of Le Maire, north 20° east, 126 miles.

In proceeding from the Straits towards Cape Horn, I would strongly advise vessels to take the route inside of the Hermit Islands, by Nassau Bay. A vessel standing to the westward, for Nassau Bay, by keeping close to New Island, would avoid the currents which set strong outside a line drawn from Cape Good Success to Cape Deceit, the easternmost land near Cape Horn; and even if intending to pass to the south of Cape Horn, with a contrary wind, it would be better to pursue this course. All vessels ought to beat up to this Cape within the above line, as they would thereby very much shorten their passage, and be enabled to round the Cape, or to await the first good opportunity that offered, without being subjected to the great wear and tear from an exposure to the heavy seas and strong gales that must be encountered to the south. The dangers are all visible or pointed out by the kelp; the sea is comparatively smooth, although the squalls are violent and charged with hail, rain, and snow; but there is ample room for working a ship, and no danger to be apprehended from a lee shore. The winds, together with the tides, will assist very much in making progress to the west, and the smoothness of the water will avoid much wear and

tear to a vessel. There are several anchorages that are convenient and perfectly safe: New Island, Goree Roads, Gretton Bay, Sea-Gull Harbor, Orange and Scapenham Bays; the two latter may be known by the "Sentry boxes" which are conspicuous craggy peaks behind Scapenham Bay. This course would be much more desirable at some seasons of the year than at others, and particularly during that portion of the year when daylight prevails.

In fine weather, the passage outside the Hermit Islands and round Cape Horn is attended with no difficulty, and the Cape may be closely approached. The Squadron was much favored, and passed within three miles of it.

I should not have taken the outside route around the Cape if the Admiralty Charts had been in my possession, as I very much preferred that through Nassau Bay.

The Relief had previously reached Orange Harbor, by the inner route, from Good Success Bay. She anchored for a day under New Island, where they obtained observations, by which I find an error in longitude of 6′ west, as laid down on the Admiralty Charts. As New Island is a well-defined object on which to get bearings, it is important that its position should be accurately given. The situation of Orange Harbor is easily known by Packsaddle and Burnt Islands: the former lies some five miles to the north, and cannot well be mistaken, from its remarkable appearance; the latter protects and forms the harbor, and is readily recognised by its smooth surface. In entering, either side of Burnt Island may be taken, but I recommend that to the north, bearing in mind that there are no dangers without the line of kelp. The best position in which to anchor is towards the head of the harbor.

Orange Harbor lies in longitude 68° 02′ 40″ west, latitude 55° 31′ south. The tide rises 4 feet, and it is high water, full and change, at 4 o'clock. The flood runs to the eastward 5 hours.

The water we procured here, although apparently highly impregnated with vegetable matter, was found quite wholesome.

It is scarcely necessary to add that it was almost impossible, from the fickleness of the climate, to get a series of observations, and that we considered ourselves fortunate in making as many as were requisite to ascertain the rates of our chronometers.

Vessels desiring to stop for repairs, or wood and water, will find Orange Harbor far preferable to any other port on the coast. It is both convenient and safe, and affords every facility to procure those articles, as well as scurvy-grass, wild celery, and berries; and fish may be also taken in abundance. Temporary anchorage is found in the Bay outside Burnt Island. The stay of a part of the Squadron in

Orange Harbor for 60 days, during the months of February, March, and April, afforded us an opportunity of testing its advantages. During this time the weather was extremely changeable. The wind prevailed 47 days from the westward, 12 days from the northward and westward, and but 1 from southeast. Eleven gales of wind occurred, of from 2 to 3 days' duration. Nearly all navigators report that the summer is the best time of the year to make the passage round Cape Horn; but it is doubtful, as it would appear almost impossible for gales of wind to be more frequent than we experienced them.

But to return to the inner passage. I here speak of it in contra-distinction to the outward or southern one round Cape Horn. Once having reached Gretton or Orange Bay, the first opportunity of a favorable wind and tide which offers may be taken, of passing out of the western channel, round False Cape Horn, to the southward and westward. With the wind from the northward and westward, a course may be made good to the west of Diego Ramirez, and under favorable circumstances even to reach the Ildefonso Isles. It is advisable to stand as long as possible to the west, provided a vessel does not go to the southward of latitude 58° south; if the longitude of 75° west has been reached, it would be better to stand to the northward again, and close with the coast: no apprehension of a lee shore need be entertained. All navigators who have had any experience on this coast, from Cook down, agree as to the wind not "blowing home," and the fact of the currents setting off shore to the southward would make it impossible for any vessel to incur danger, with ordinary care. When the gales blow from the westward, they seldom continue long from the same quarter, but vary from the northwest to the southwest. This offers many facilities in making the passage, and advantage should be taken of these changes, standing upon that tack which gives the best opportunity of making westing.

From a careful examination of the tracks of very many vessels that have passed the Cape, I am well satisfied that much time, besides great wear and tear of the vessel, and fatigue to her crew, will be saved by following the inner route, and continuing along the coast as far as Cape Pillar. Some objections have been made to approaching the southern shores of Tierra del Fuego, to the east of the Hermit Isles; but they are bold and high, and no hidden dangers exist to cause alarm. The danger attending the passage through the Straits of Le Maire from the velocity of "the races," caused by the tides, many deem the great objection to attempting this inner route; but I cannot conceive why, if the weather will permit carrying sail at all, there can be no difficulty in beating to the westward, within the line I have indicated,

between Cape Good Success and Cape Deceit. Once up with the Hermit Islands, and being overtaken by night, it would be well to seek anchorage in either of the bays spoken of, and await daylight or a favorable time to proceed. The only inconvenience that a vessel can be put to is in getting her ground-tackle ready for use, which is not to be considered in comparison with the wear and tear, if exposed to the violent storms at the south. In nine times out of ten, the passage round Cape Horn, by taking this inner route, will be not only much shortened, but deprived of its hardships and terrors, and subject to much fewer casualties than that by the outside.

Captains King and Fitzroy deserve great credit for the perseverance and ability displayed in conducting the surveys in these boisterous latitudes, the results of which are embodied in the Admiralty Charts, with the directions of Captain King.

The charts of Captain King, and his sailing directions for Eastern and Western Patagonia, are admirable guides through this navigation, and are very necessary for every navigator in doubling the Cape, or when frequenting this inhospitable coast.

As far as our experience goes, the barometer is extremely useful, and indicates truly the weather. Those in the habit of using it in northern latitudes would be inclined to doubt it, for its indications are directly opposite: fine weather accompanies its fall, and a gale is seldom felt until it has begun to rise, when the wind veers several points and increases till it blows with great violence; this continues until the mercury has attained its ordinary height.

There is another view of this subject, that will probably show the utility of adopting this route, viz., that it places the vessel in a situation, the moment a gale has subsided, to take advantage of the short space of fine weather that succeeds, and in all probability to make the desired westing, before a recurrence of storms; for the distance to be run is but some 350 miles, and may be passed over in a very short time.

There seems some difference of opinion relative to the longitude to be reached before keeping off to the northward. In most cases, it is that of 80° west, in the latitude of 57° south; but during the winter season, from April to October, as the north and northwest winds prevail in the Southern Pacific, it would be better for vessels to attain the longitude of 82° west before steering away to the northward, thus in all probability avoiding the heavy northwest winds which blow near the coast of Chili, saving much time, and sooner enjoying fine weather, which is generally less boisterous as the distance from the coast is increased. My own experience is decidedly adverse to nearing the coast, or being

forced upon it by westerly winds. For nine days (from the 2d to the 11th of May), between the latitude of 40° and 47°, we had constant and unintermitting north winds.

Another argument I would urge in favor of these views is, that nearly all the disasters that have happened in passing the Cape, have occurred to the eastward of Diego Ramirez, where the currents are found to have greater strength, and the winds appear to hold longer from one quarter, and do not veer, as has been noticed in the preceding remarks.

At all seasons, the navigator may be assured that he is not so liable to meet with icebergs, — one of the most serious impediments in the spring and summer months. In the year 1832, the ocean was found so covered with them, that many whaling vessels, bound round Cape Horn, encountering them, put back to Valparaiso, there to await a more favorable season, considering it too dangerous to involve themselves with the numbers that were seen.

From our experience of the weather, after we left Orange Harbor, I cannot represent it as being stormy: it was boisterous, as one always must expect it to be in these high latitudes, and off the extreme end of the continent, it is subject to great vicissitudes, and the seas produced by the meeting of the waters of two great oceans are heavy.

In the Vincennes, we were but eight days in attaining longitude 78° 30′, in latitude 56° 30′ south, when we bore up to the northward. This longitude will not leave as much room as is to be desired to weather the coast of Western Patagonia to the north of Cape Pillar. The gales that prevail during the winter season are from the west to northwest: these have a tendency to force the navigator on the coast, although there can be no apprehension of suffering from a lee shore. Yet I deem it safer to avoid the chances of it, notwithstanding I was successful in the course I took. It ought to be recollected, that after getting to the north of the parallel of 40°, the most stormy latitudes have been passed, and the navigator is relieved from his excessive toil and watching.

On the whole, although the passage around Cape Horn is boisterous, I cannot bring myself to look upon it as so surrounded with dangers as has frequently been represented, and do not believe that the great precautions recommended to be taken are necessary; at the same time, the navigator should not be off his guard, or avoid putting his vessel in the best possible condition to meet with bad weather. The precautions alluded to, however, are the striking below of the guns, and other like acts: these I cannot believe to be at all necessary. The ordinary winter weather experienced by vessels navigating our own coast and

the North Atlantic, is as severe as that encountered in passing the Cape. To draw a comparison between the two would be impossible— they have so few points of similarity. The exposure in passing round the latter is little when compared with the former.

By the ordinary route pursued, doubling the eastern end of Staten Land (Cape St. John), it frequently takes from 20 to 25 days — say from the longitude of 62° to 80° west, on the parallel of 54° south, a distance of about six hundred miles. Anything short of this time may be considered a good passage, supposing a vessel to meet with a full share of boisterous weather: there are times, however, when the weather is equal to that of the Tropics; indeed, on our first arrival off this dreaded promontory, it was of this character, but our stay was long enough in these desolate regions to satisfy every one that its fickleness is not to be surpassed in any quarter of the globe.

Anchoring on the western coast of Tierra del Fuego is to be avoided. Noir Island is a dangerous anchorage, as was sufficiently proved by the Relief. For an account of her disasters, see Narrative, Vol. I., page 161.

The current from Cape Horn to Valparaiso was south, 72° east, 364 miles.

We entered the Monsoons of the west coast in the latitude of 36° south.

FROM VALPARAISO TO CALLAO.

From June 7th to June 20th, 1839.

Our stay in Valparaiso was twenty days. When this place was first visited by American vessels, they anchored towards the head of the bay, before the town; this exposed them to all the violence of the southerly Monsoons during the summer season, and also during the northerly Monsoon to the heavy sea that then prevails.

The precaution requisite in approaching this harbor, is to make the coast to the southward. If it should be late in the day, and there is no prospect of reaching an anchorage, it would be advisable for vessels to keep off the land some 8 or 10 miles, with the light on Point Angelos bearing southeast, as they would then be beyond the influence of the strong northerly current that sometimes prevails near the coast, and is of great strength within 6 miles of the land; and in the event of calm, which is frequently the case during the night, a vessel may be set very far to leeward of the port before daylight by being exposed to it, and placed in a somewhat critical situation. Near the beach of Concon, or that of Quintera, the current is usually strongest about the time of

new and full moon, when a most remarkable increase of the surf occurs on this coast; indeed, as far as my observations have extended, the entire west coast of South and North America is subject to this phenomenon.

The anchorage is now under the bluff to the north of Point San Antonio. During the winter season, thick, rainy weather, with fogs, are frequent, attended with little or no wind, making it extremely difficult to get out of the harbor or bay during its continuance. The summer season is remarkable for the regular southeast Monsoon: the morning being usually calm and pleasant until about 11 o'clock, when a breeze comes up from the south, gradually increasing to a strong gale, with perfectly clear weather. During the continuance of these high winds, the discharging of cargoes, and even intercourse with the shore, are for the time suspended; it becomes, therefore, necessary, in anchoring in the bay, during the summer months, to give a longer scope to the southeast cable; and in the winter months, to moor with the heaviest anchor to the northward and westward.

Gales from the north, termed "*northers*," occur seldom, once in several years. In June, 1823, I experienced one of the most violent and destructive gales that ever happened at this place, in which eighteen vessels — nearly all of them large and fine ships —were cast on shore, in consequence of their cables having been chafed off — chain-cables not being then generally in use, and the bottom much fouled by lost anchors. The risk in this harbor from such causes is much less now, on account of the nearly-universal use of the chain-cable.

The northers are indicated by a fall of the barometer, with a day or two of dull, heavy weather, and an increasing swell setting into the bay, giving timely warning to prepare by securing boats on board and everything else, for riding at anchor in a heavy sea. The immediate precursors of it are a lighting up of the clouds and a bright clear sky to the northward and westward, and the looming of the land to the northward off Concon and Quintera, which is not usually visible from the bay. The worst riding is experienced on the flood tide, the sea setting in very heavy. It is somewhat more moderate with the ebb, which, setting to windward and acting as an undertow, prevents so great a strain on the cables; the sea is shorter, but nevertheless vessels ride easier.

From the experience I have had in this bay, some precautions are necessary in anchoring, and it would therefore be well to observe the following directions. In the summer season, a single anchor to the southward and eastward is alone necessary, having a long scope, as the winds are strong from that quarter, and frequently come in heavy gusts off the highlands, rushing down with great force, when vessels

are liable to drag off the bank, which is steep. If anchoring to the north of Point San Antonio, you moor with open hawser to seaward; if to the south of it, in the summer season, it is better to ride at single anchor, steadied by a kedge. In winter, care should be taken not to be in the hawse of other vessels: the harbor regulations being indifferently attended to, it is difficult to keep a clear berth. Vessels frequently suffer great damage from collision, as any vessel breaking adrift must necessarily come in contact with many others. All should endeavor to moor in a clear berth, so as to be able to ride with a cable on each anchor—say from 90 to 100 fathoms—to insure the certainty of not dragging; the usual depth of water is from 15 to 30 fathoms, mud and sand.

The anchorage for men-of-war is to the north of Fort San Antonio.

It is high water, full and change, at 11 hours 30 minutes, A. M.; and the rise of the tide is 4 feet 9 inches.

Provisions of all kinds are plenty. Wood, however, is dear and with difficulty procured. Water can be obtained by the boats of a vessel; but it is a great saving of time and expense to have it brought off in tanks. The price is one dollar per tun.

The current between Valparaiso and Callao was found to be north 82° west, 162 miles.

The Monsoons, at the season of the year when we passed over this route, were uncertain and unsteady, but they generally prevailed from the southward and eastward. When the wind was not strong, the breeze would veer to the northward and eastward for a few hours. The sky was for the most part overcast, though the weather was mild and pleasant.

During the winter, April to October, it is better to steer directly off from the coast until you reach an offing of from 100 to 150 miles, and then make a direct course for your port; by this means you get within the influence of the regular southerly Monsoon, which is generally found at this distance from the coast, and beyond the influence of the northerly one, which prevails near the land; you are then sure to have a favorable breeze to carry you forward to your destined port.

The Vincennes was 13 days on this passage; but it is frequently made in 8 days.

At Callao we remained from the 20th of June till the 19th of July; during the greater part of this time we experienced thick, misty weather, so as to render it difficult to obtain the necessary observations for rating our chronometers. The longitude deduced by them was 77° 11′ 10″ west, and the meridian distance between Callao and Valparaiso, 5° 31′ 50″.

The Bouqueron Channel seems to be seldom used by large vessels; yet, coming from the windward, it is certainly preferable to passing round Point Galena, the north point of San Lorenzo. The directions for passing through it are extremely simple: stand in to the southward of Isle del Fronton until La Horadada Rock and Point Morro Solar are in one; then steer directly for the inner point of San Lorenzo, until the town of Callao is seen to open with the Castle, when haul in and anchor in the roads, in any berth that may be convenient.

I passed through the Bouqueron Channel after dark, and over the tail of the shoals at its entrance in $3\frac{1}{2}$ fathoms, anchoring opposite the burial-ground on the Island of San Lorenzo. Our observations place the wharf in longitude 77° 16′ 45″ west, and latitude 12° 4′ 46″ south.

Callao Bay is at all times smooth; the sea-breeze sets in usually about noon, and continues until towards sunset; the nights are for the most part calm and pleasant, although frequently the almozo or dew is heavy. With the exception of not being able to land the stores of a vessel conveniently, it is one of the best ports of the Pacific to effect repairs in. Water is here obtained from pipes at the mole with ease, and is good; wood is scarce, and consequently dear. The markets are well supplied with provisions, and tropical fruits are abundant, when there are no intestine wars to disturb the country.

FROM CALLAO TO TAHITI, THROUGH THE PAUMOTU GROUP.

Between the 19th of July and the 10th of September, 1839.

The time employed in making this passage was 53 days — this includes that spent among the islands of the Paumotu or Dangerous Archipelago, amounting to some 25 days. Our route lay between the parallels of 12° and 18° 30′ south latitude. Within these parallels I hoped to have been favored with a strong Trade Wind; but the winds at this season of the year (July), on the parallel of 18°, cannot well be so termed, although generally prevailing from the eastward; the effect of the southwest wind is evident by the interruptions, and the long swell from that quarter. The sky was unattended with the usual light clouds that are met with in the Trade Winds: instead of this, we had the scud flying at times rapidly from the southwest. I would therefore advise that vessels having the intention of stopping at Tahiti, as this group lies immediately in the route between it and the coast of South America, it becomes of advantage to pass through the islands which are embraced within it.

During the summer months of the southern hemisphere (from Decem-

ber to March), the weather is the most boisterous: the Trade Winds are usually fresh from the east, and east northeast to east southeast; but a vessel cannot calculate upon them with any degree of certainty, being often interrupted by the winds from the northwest and southwest. The currents are not strong, nor do they at any season affect a vessel, and, from all the authorities I have consulted, as well as our own experiments, I am inclined to believe that no allowance for current need be made. Some slight current will at times be experienced near some of the islands, during or after a strong wind, but it will be found to be both local and variable.

During the winter season (from March to September), the Trade Winds are by no means regular among these islands; they seldom extend so far to the south, are very often prevalent from the southwest, the weather is frequently very unpleasant, inclining to calms and light winds, with an occasional squall; it is, however, the fine season—for in summer, gales from the west not unfrequently occur, blowing very heavy, with rain, and interrupting the course of the Trades, often causing a failure to obtain the usual observations for latitude.

A vessel desirous of passing through this group, will find the 20th parallel most free from dangers, and can continue on it until reaching 141° of west longitude, when a direct course to Tahiti may be steered; on either side of this parallel, north or south, Whitsunday and Carysfort Island may be sighted, in about 138°, and afterwards Teku or Barrow Island on the south, and Nganaiti or Byam-Martin on the north, and further to the westward, Heretua or Archangel and St. Pablo: all of these can be seen from seven to ten miles.

The next route is on the parallel of 18° 30′ south, making the Island of Clermont de Tonnerre in 136° 30′ west longitude, passing by Serle Island, and steering direct for Hau or Bow, then pass Dawhaidia, or the Two Groups to Tahiti. The only dangers on this route are the Buyers; but I think their existence is very doubtful: the space where they are situated, I have every reason to believe, has been passed over frequently; though having no knowledge of absolute search having been made for them, they are retained on the chart.

There is another route on the 15th parallel, sighting Henuake or Honden, whence a due course may be steered for Aratica or Carlshoff, or the north end of Taiara or King's, thence passing to the north of Kawahe or Vincennes, to the east of Toau or Elizabeth and Niau, or Greig Islands, to Tahiti.

These are the routes to be pursued with a favorable wind, but it frequently becomes necessary for vessels to pass through this group when bound to the northward or southward. Vessels coming from the

North Pacific, for instance, from the Sandwich Islands, rarely can get so far to windward as this group, and if they could, would seldom wish to take the risk, and would not desire to be subjected to a navigation so beset with dangers. When bound from the north, I would recommend making Nairsa or Dean's Island, and passing through between it and Tikehau or Krusenstern's, as being the most safe and advisable to follow. If it is desirable to cut the group more to the eastward, Ahii or Peacock Island may be sighted, and the passage between Nairsa and Arutua taken. If still on a more eastern meridian, I would recommend passing between Raraka and Saken Islands, previous to which both Tike and Taiara may be sighted; and after passing through the channel between Raraka, Saken, and Tahanea, the wind will generally permit a vessel to pass to the eastward of that island, when the sea will be clear until the 20th parallel is reached.

Another route still more eastward may be recommended, which is making the Disappointment Group, and holding a southeasterly course, to make Ahangatou, and thence pass Amanu, Hau, Harris, Nganaiti, Teku, Hercheretua, Matilda, and Cockburn Islands. Great doubt still exists concerning the Island of St. Juan Batiste: it has not been seen since the time of Quiros, 1606; but I have not felt authorized to expunge it from our chart, for we ourselves verified his discoveries of the Four Crowns, Archangel, and St. Pablo.

On the routes that I have pointed out, reference has been had to the winds, and the probability of a vessel experiencing those prevailing in this part of the Pacific. It is very evident that the islands may be passed through in all directions by those who are acquainted with them, or feel disposed to incur the risk; but I have felt it my duty to sketch what in my opinion are the safest routes, and those I would myself endeavor to pursue. On these routes there are islands where a vessel may obtain a shelter, as well as all the products that are to be found in this group.

In entering the lagoon of any island, it would not be advisable to attempt it, unless the current should have ceased setting in; off the entrance, the direction of the current will always be known by the race that is readily perceived either on its influx or reflux.

The passage from the coast of South America to the Society Islands is ordinarily made in about 40 days.

The Island of Tahiti is the most resorted to, particularly its harbors on the north side, from Point Venus on the north to Papieti on the west. This island may be seen some 80 miles in clear weather, but ordinarily not beyond 40 or 50 miles. The peaks are seldom seen, being usually covered with clouds. In approaching Tahiti, it is decidedly

advantageous to do so from the eastward, as you then have no difficulty in reaching your desired port; and although pilots will be generally found in the offing, yet no one need have any hesitation in running in, provided a good look-out is kept from aloft. The shoals and reefs are all laid down on the charts, and may be easily avoided.

There were no perceptible currents experienced during the period we were cruising among the Paumotu Group. We had many opportunities of trying the current, but none was found; neither did the position of the ships, when hove to, or beating to windward, indicate any, and I feel warranted in the belief that at other seasons of the year none will be found to exist. The operations of the Porpoise were not at all impeded by it in this group in the months of December and January.

On this passage we had an opportunity of verifying the positions of the Island of Clermont de Tonnerre and that of Serle Island, and to prove the non-existence of Minerva Island. Whether the latter is identical with either, is a matter of little moment to navigators; the existence of a separate island it was necessary to disprove, and in so doing, it involved the position of the two others; and although neither can be, from the description, identified as Minerva Island, yet, if it existed, it must, from its position, lie between them. In order to reconcile the various observations, it is most probable that the Captain of the Minerva saw the northwest end of Clermont de Tonnerre, as his description of the island is totally at variance with the truth, unless this is admitted; both the latitude and longitude would warrant the belief that such was the case. I have therefore supposed it identical with Clermont de Tonnerre, and not Serle Island.

The currents on the passage from the coast were variable, and nearly neutralized each other; the amount we found to have influenced us during the passage was north 57° east, only 17 miles. At other seasons of the year the currents may be stronger and more in favor of the vessel bound to the west; to judge from our experience, it would appear that these westerly currents are influenced by the westerly Monsoon, for the currents that are believed to prevail during this portion of the year in the Pacific set in an opposite direction.

The prevailing winds among these islands are from the east southeast to east northeast during good weather; from any other quarter the weather is usually unsettled, cloudy, and rainy, with occasional gales from the southwest, north, and northwest. The months of December, January, February, and March, may be termed the bad season: it is then that the north and northwest winds prevail. The rest of the year the weather is fine, although occasional southwest winds are expe-

rienced, bringing rain; these are usually followed by light westerly breezes; during their prevalence, the weather is extremely sultry and warm.

Tahiti is indebted for its fine harbors to the coral reefs, and only where these are detached from the shore are they found. The south side has no harbors, the reef being in some places wanting, while in others it is attached to the shore. On the north, however, the harbors are continuous, viz.: Matavai, Papaoa, Toanoa, and Papeiti, extending from Point Venus to the west 8 miles. There are other harbors on the east and southwest sides, but they are more or less exposed to the influence of the easterly and southwesterly winds: those on the northwest and west sides, with the exception of Matavai Bay, are at all seasons quite secure.

Matavai Bay is protected to the north and east by Point Venus and the projecting reefs off it, as well as somewhat by the Dolphin Bank to the northwest. With the Trade Winds it is a convenient harbor for a vessel to seek, as there is no difficulty whatever in entering or departing from it. The least depth of water found on the Dolphin Shoal was 13 feet 6 inches. It may be passed on either side; if to the eastward, the reef ought to be kept close aboard and a look-out from aloft; intending to anchor, it is better to turn short round the reef, and pass through this passage, as a vessel thereby avoids any necessity of beating up; the bay is entirely clear, with the exception of two small shoals lying to the north of One Tree Hill, on which there is not over 3½ fathoms water: the depth in the bay varies from 6 to 18 fathoms. The anchorage is good in any part of the bay, but it is better to anchor well up towards Point Venus, the bottom black sand with mud.

Water is to be had without difficulty from the river that empties behind Point Venus, and can be obtained by passing over the sand beach, where the stream has the appearance of having formerly flowed. Natives may be employed to fill the casks, being expert and faithful in their labor; it is necessary, however, for an officer to superintend them. Wood can be purchased here for four dollars a cord, of the chief, who brings it to the beach and there piles it.

The bay is surrounded by a beautiful beach, extending from Point Venus to the foot of One Tree Hill; a boat, in the fine season, may land on any part of it without difficulty, but from December to March it becomes difficult at times to communicate with the shore.

The harbor of Papaoa lies next to Matavai Bay on the west. It is formed by coral reefs, and though small, is well sheltered; the entrance lies on the east. There is plenty of water for a large vessel, but the passages, though not intricate, are narrow. The only way to navigate

through them is to choose a moderate breeze, and have a good look-out from aloft. The best anchorage is off Queen Pomare's House, in from 7 to 12 fathoms water, which is near the watering-place. The reefs afford the harbor all the protection from the sea that could be desired. There is a passage through to the harbor of Toanoa, lying to the west, but the turn through the reefs off Alaheda Point is very short, narrow, and difficult to pass. The chart of this harbor shows the channel more clearly than any description.

The fine harbor of Toanoa has an entrance of much greater width, and is consequently much safer than that of Papaoa. There are some coral rocks lying off the east point of the reef at the entrance: care must be taken to avoid these; and vessels bound in, after opening the mouth of the harbor, have only to haul up for the houses on the beach, on a south southeast course, where they can anchor in from 6 to 10 fathoms water. Toanoa is more exposed to the north than Papaoa, and a heavy sea rolls in, which renders it uncomfortable for a vessel in the bad season. The bottom is good holding-ground, black sand, with mud. The watering-place is convenient, though attended with some difficulty in consequence of the coral, which forms the beach. There is a deep and broad passage between this harbor and that of Papeiti, a mile and a half in length, and suitable for any class of vessels, though all navigation among coral islands and shoals requires great attention: it is not to be disregarded in this case. The entrance into the channel from Toanoa is narrow, but the passage between the coral shoals is readily perceived. The best course is to keep close to the outer reef, whose edge is for the most part well defined; but this passage should not be attempted in the afternoon, when the rays of the sun make it impossible to see the coral shoals that are to be avoided. As soon as the harbor of Papeiti opens, the Government wharf may be steered for, and when to the southward of the middle coral shoal, the anchor may be dropped in 8 and 9 fathoms water.

In approaching Papeiti harbor from the north, its position is well pointed out by the Red Hill and Crown, which lies immediately behind it, but as vessels seldom make the island otherwise than from to windward, it is not deemed necessary to give any particular marks for entering by the north, as they would or might tend to mislead; the whole attention is to be given to the reefs along which the ship will be making rapid way, and the distance being short, there is but little time even to make preparations. Tow-lines and boats should be ready, as, in the event of being obliged to anchor near the entrance, it becomes necessary either to tow or kedge to a suitable berth. If any vessels

are lying in port, aid from them in the way of boats may be confidently relied upon.

The north entrance is somewhat dangerous: the current setting obliquely across it, is very apt to throw a vessel on the sea or western reef, if due attention is not paid to turning short round the eastern point, giving the ship all the way possible, in order to shoot her well into the harbor. Every sail ought to be ready to clew up and hand, and the anchor to let go, before the attempt is made, as it is quite possible that the moment the vessel hauls up with yards braced sharp, she may meet a light breeze off the land, which, taking her aback, would endanger her being driven out, or on the lee reef: this is more particularly the case when the Trade Winds are strong, as then the wind is apt to draw off the land. The entrance from the north is the usual one, but I feel satisfied myself that the one by Toanoa harbor is the safest and least objectionable.

I have not spoken of the native pilots, who are in attendance, but they are not to be relied upon, except to point out the channel, and all masters of vessels must attend to the working of their ships.

The harbor of Papeiti is one of the best ports of the Pacific. It is perfectly sheltered from winds, — for picturesque beauty cannot be excelled, and has sufficient depth of water for any class of vessels, and, as far as the Islands can have, under the present government, every facility for making repairs. Water may be had in abundance and without difficulty, and supplies of all kinds are readily procured. Being the residence of the Queen and foreign consuls, all the trade centres here.

At Papeiti there are many supplies to be had in the way of repairs, and what the place does not itself afford may, in all probability, be obtained from whalers, or the men-of-war that are met with in the port. It has, however, one great disadvantage, in being deprived of the Trade Wind, being too far under the lee of the island to be benefited by it; the heat consequently is at times intolerable and very enervating, while in the harbors to windward the temperature is very much modified, and in comparison invigorating; on this account, I should advise vessels merely stopping to refresh their crews, and not requiring repairs, to visit one of the windward harbors: of these, I should prefer Toanoa.

The position of the small island of Motuutu, on which there is a small fort, renders the harbor of Papeiti susceptible of being well defended from an attack by sea, but the place is not tenable from an assault by land.

There is an extensive shoal to the eastward of Point Venus, on which the French frigate Artemise struck.

This northeastern reef extends from 1⅛ miles east, half north, of Point Venus to abreast of the valley of Hapaino, which is distant about 10 miles from Point Venus. It is detached from the land, and for the most part lies parallel with the shore, except near its centre, where it deviates to the north northeast, for about a quarter or half a mile. The soundings on it decrease very regularly, the centre is the shoalest part; from thence they gradually increase from 3 to 12 fathoms, all coral bottom; on or near the centre, which lies directly off a remarkable table-land, it has for a considerable distance from 3 to 4½ fathoms; on the eastern side the shoal trends for a short distance to the south southeast, south, and southwest. The outer part of the reef is about 3 miles from the shore. When on its centre, Point Venus will just be on with the high peak of Eimeo, bearing west by south three-quarters south. To avoid this shoal, all that is necessary is to keep the bearing of Point Venus to the south of west southwest. The passage inside leads to no shelter or harbor, and every precaution ought to be taken to avoid getting within it. If, however, a vessel should by any chance find herself there, she may continue her course to the westward, as the passage is perfectly safe and free from danger, until deep water is found, which is said to exist at the western end of the shoal, in the proximity of Point Venus. I should deem it better, however, if the sea is not high, to cross the shoal at any point some distance from its centre, as the water, for an ordinary-sized ship, will be found sufficient. The reef is from half to three-quarters of a mile wide, and as the sea seldom breaks on it, is particularly dangerous to vessels running along for Point Venus, when they have closed with the land to the eastward.

There is another shoal, called Tecalai, lying off the valley of Tecalai, which, though more dangerous, is at the same time more out of the track of vessels. It becomes necessary to notice it, as vessels sometimes make the land to the eastward, in thick and cloudy weather. This shoal, like the former, lies parallel with and about 3 miles from the shore, with a clear passage inside; there is a good channel between the two. On its shoalest place there are but 2½ fathoms; like the other, it seldom breaks. It is half a mile wide and 5 miles in length. The marks by which the position of the shoalest part may be known are, the high peak on Tiarabu, with the two small islands of Bovulon and Taawirry, bearing south southeast, half east, and a remarkable black mould hill near the beach, nearly perpendicular, bearing northwest, half west; the water is deep at both ends.

In the survey which we made of the harbors of Tahiti, our operations did not go east of Point Venus: my time would not admit of any extension in that direction. Captain Kotzebue, of the Russian Navy, in the

year 1824, extended his survey a short distance to the eastward of Matavai Bay, and has named a small harbor on the east side of Point Venus formed by an islet, Port Papeiti: this is liable to lead to error, as the true Port Papeiti is several miles to the westward, and I am satisfied this name was adopted without due consideration, or perhaps before the port of Papeiti to the westward was known. This small port, if it deserves the name, is, when compared with any of those to the eastward, totally unfit for anchorage, being more exposed to all the winds than either of the others, and of course less secure.

The tides of Tahiti have little rise or fall, and apparently are not under the usual influences: they are generally affected by the Trade Winds, which cause the anomalies that have been noted. They will be noticed in their proper place. I would call the attention of navigators to the interesting observations that may be made in Matavai Bay, relative to the growth of coral on the Dolphin Shoal, at some future time. Of this an account has been given in the Narrative, Vol. II., to which I would here refer.

FROM THE SOCIETY ISLANDS TO THE SAMOAN GROUP.

Between the 29th of September and the 10th of October, 1839.

Vessels bound to the westward will leave the harbor of Tahiti as soon as the sea-breeze or Trade reaches there: this is during the forenoon, and when it is well advanced. If in the harbor of Papeiti it would be better, from its being so far under the lee, to get under way at an earlier hour, taking advantage of the land-breeze, which will generally be found to extend beyond the sea-reef. The weather harbors and bays get the full force of the Trade Winds, which almost constantly prevail. In standing to the westward, pass to the northward of the Island of Eimeo. The Trades generally blow fresh, except during the months of November, December, and January, when it would be advisable to take the route to the northward of the Society Group, and get into a lower latitude, especially during the above months, the summer of the southern hemisphere. When in latitude 13° south, a course to westward may be pursued.

The passage to the Samoan Group requires usually 6 or 8 days,—a distance of 1200 miles. The latitude of 15° south will avoid all the islands and reefs; between these two groups the winds will be generally favorable, but there are exceptions, and bad weather is frequently encountered. When we made the passage, in October, we encountered much rain and winds from the northwest, south, and southwest; but very little regular trade. The Peacock and Flying-Fish made the

passage 10 days later, and had very strong Trades all the way. It seems that little dependence is to be placed in the winds at this season, south of the parallel of 15° south; indeed, I should advise navigators to avoid the belt of ocean between the latitudes of 15° and 18° south: the Trades are not to be depended upon south of the former, nor is there any certainty of winds from the westward in any season. Many anomalies seem to take place to the westward of the Paumotu Group, although I am not inclined to believe that they can arise from any influence that is exerted by that group, for, as I have remarked, this same vacillation of the winds seems to exist between this archipelago and the coast of South America, between the same parallels. The currents during our passage were from the south, but trifling; and we found the sea remarkably smooth and the winds variable.

This fine group consists of eight islands, viz., Savaii, Upolu, Tutuila, Manua, Oloosinga, Ofoo, Manono, Apolima, and Rose Island. They are all volcanic, except the last, which is a small coral island, with a lagoon. Savaii is the most western and largest, and Rose Island the most eastern and smallest. They are embraced within the longitude of 168° and 173° west, and between the latitude of 13° 30′ and 14° 30′ south.

Rose Island may be run for in the day-time, — its rounded clump of trees can be perceived at a long distance: its longitude is well established. It is better to pass and keep to the southward or windward of it and Manua; and if bound to Tutuila, can then enter Pago Pago harbor; if to the harbor of Apia, in the Island of Upolu, pursue the same course, and then between Tutuila and Upolu.

All these are inhabited except Rose Island. The two most important are Upolu and Tutuila, both as regards their productions, as well as the number of fine harbors they offer for vessels; with but one exception, they are formed by the coral-reefs: this exception is the harbor of Pago Pago, on the south side of the island of Tutuila. It is completely land-locked, and in shape somewhat resembling a retort; its situation may be known by the Peak of Matafoa, which rises directly above it. It is on the windward side of the island, — therefore, the wind is generally fair to enter, but difficult to depart from. The entrance cannot well be seen until near to it, when the tower rock will be seen standing out boldly and isolated on the western shore reef. Between it and the Devil's Point on the east, is the opening. They are half a mile asunder; it is necessary to shorten sail quickly, as there will be but little time before the elbow is reached and Observatory Islet is passed. Care must be taken to avoid the rock which lies in mid channel, just within the two outer points. If there is any sea on, it will show distinctly; but otherwise, it will only break occasionally.

There is but 10 feet water on it, — it is the size of a long-boat. Having passed Observatory Islet, proceed up and anchor in any convenient berth between it and the head of the harbor. The egress from this harbor, as remarked above, is difficult, if not dangerous. It should never be attempted except with the ebb—and unless a vessel can turn to windward well, the attempt will give much anxiety. Three miles to seaward, off the entrance, lies a coral bank running parallel with the island, but there is sufficient water for a vessel to pass over it when there is no swell.

Apia harbor, in the Island of Upolu, though small, is the best to visit. The principal chief and consuls reside there, and the necessary supplies may be more readily obtained. The entrance is easily known by the break in the reef, which shelters the anchorage. The access to this harbor is easy, and the departure equally so. I would not, however, recommend it during the stormy season, from December to February.

These islands afford all kinds of refreshments in abundance, particularly those that are the productions of Polynesia, and since the establishment of the missionaries, the attempt to introduce neat cattle has been so successful, that they will be shortly able to supply beef at a reasonable price.

The weather from April to December is generally fine, but from December till the end of March, long and heavy rains prevail, and the gales are frequent from the northwest and west, with much bad weather. The climate may be termed variable: the mean temperature is between 75° and 82°, and the mean height of the barometer 30·128 inches. Destructive hurricanes are at times experienced on these islands, as well as in the neighborhood of the group.

FROM THE SAMOAN ISLANDS TO SYDNEY, NEW SOUTH WALES.

Between the 10th and the 29th of November, 1839.

This passage was made in the month of November, and occupied 19 days. Upon leaving the Samoan Islands, we steered for Uea or Wallis Island, which consists of several islands enclosed in a reef: it is moderately high and can be seen at the distance of 10 miles. The entrance to the lagoon is on the south side, where communication and supplies may be had. From thence passed to the west of Hoorn Island, on a southwest by south course, 150 miles to the westward of the Feejee Group, and sighted Mathew's Rock, which may be closely approached. We were favored with fair winds nearly the whole distance to Lord Howe's Isles, mostly from the eastward, and southward and eastward. The winds generally increased towards evening, and the Trades were not lost until to the southward of the parallel of 25° south latitude;

then we had the wind from the northward and westward, attended with a heavy swell from the southwest, after a strong gale from the northward and westward, severe lightning and thunder; it gradually hauled to southwest, and then to the southeast. The currents were generally from the eastward, until we had passed the Feejee Group, when they came from the southward; but were of little strength.

In approaching the coast of New Holland, care should be taken not to make a land-fall to the southward, as some delay may be experienced at this season of the year (November) in entering the port of Sydney, from the southerly current, which resembles a miniature Gulf Stream: it at times flows rapidly, and retards vessels sailing to the northward from Van Diemen's Land, if they keep within it. When entering this stream a rise of several degrees of temperature takes place: this is more noticed in the winter than in the summer season. The stream is about 30 to 40 miles wide, and has an eddy on its inner edge, which is not felt beyond 6 to 10 miles from the shore. Small vessels may keep along the coast, if bound to the north. The Heads of Sydney are readily distinguished, being the most elevated land on this part of the coast.

On the east coast of New Holland, according to King and Flinders, the winds blow from the southeast during the summer months, and from the southwest and west in the winter and spring. The months of March and April are the most stormy, when bad weather sometimes lasts for a long time. The port of Sydney is at all times accessible. The lighthouse on Sydney Head gives a very brilliant light, and affords every facility to enter during the night, with or without a pilot. Captain King's chart may be confidently relied upon as accurate. We had ample opportunity to prove its correctness.

FROM CALLAO TO THE HAWAIIAN ISLANDS.

Between the 20th of July and the 2d of September, 1839.

The Relief made this passage in 44 days. She crossed the Equator in 109° west longitude, making a west northwest course. They experienced for the first four days the current setting to the west, and afterwards as far as the longitude of 104° west, to the south and southeast. The wind continued fresh from the southeast, until they reached 9° of north latitude, when they encountered south and southwest winds, until they had attained the latitude of 15° north and 124° west longitude. The currents were also variable, sometimes setting southwest, then north, and west, and again southwest. On reaching the latitude of 16° 30′ north, they entered the northeast Trades, which carried

them the whole distance to the Hawaiian Islands. Between the longitude of 125° and 130° west, the currents were variable; from thence to the Hawaiian Islands, their set was to the south.

This passage was considered a long one. It was not made with a view of following the shortest and most direct route, but of examining the locality between 130° and 135° west longitude, and on the parallel of 16° 30′ north latitude, for islands that were said to exist thereabouts. The shaded part of the accompanying map will point out the space of the ocean which has been searched for these islands. Instructions were given to deviate from the direct route for this purpose. If it had been intended that the most direct course should be pursued, orders would have been given to cross the Equator in from 130° to 135° west longitude, thence to steer direct for the Island of Hawaii. This course would carry a vessel sufficiently far from the coast to avoid the winds which affect the steadiness of the Trades more to the eastward, between the latitudes of 10° to 15° north; besides, a vessel would derive the greatest benefit from the Equatorial current. The time occupied on this route, in an ordinary sailing ship, should not be over 35 days.

FROM THE HAWAIIAN ISLANDS TO SYDNEY, NEW SOUTH WALES.

Between the 20th of September and the 31st of October, 1839.

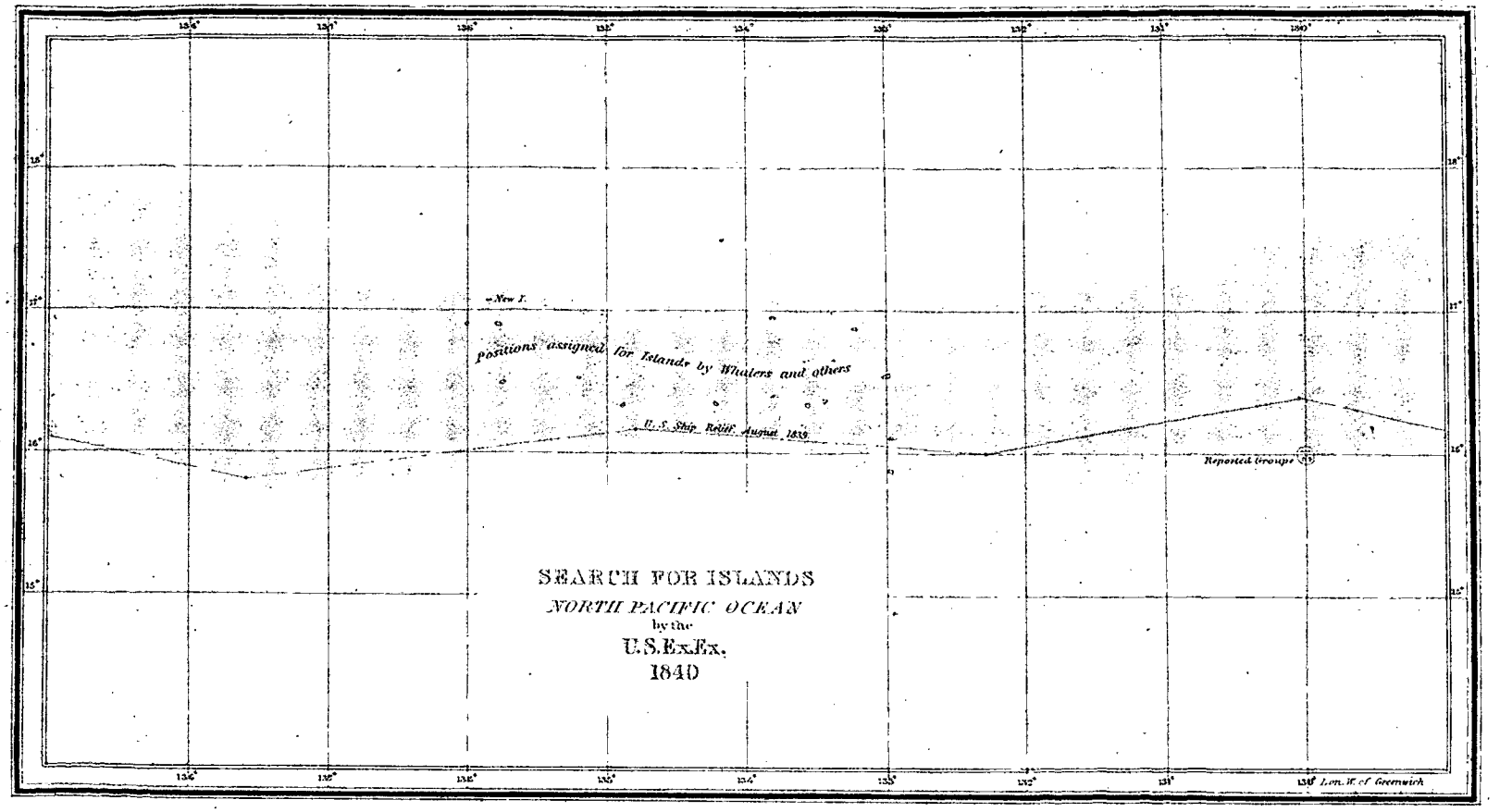
Forty-one days were occupied by the Relief in making this passage. The route was direct, passing between the Phœnix and Ellice's Groups to the westward of the Feejee Islands, and a short distance to the east of New Caledonia. The Equator was crossed in 172° west longitude, in ten days after leaving Oahu. The winds were fresh from the northeast, until reaching the parallel of 9° north latitude, when they gradually veered to the southeast, and continued from that quarter without cessation until they reached the latitude of 30° south: these were succeeded by winds from the north and northwest, which continued to Sydney.

The currents to the latitude of 9° north, were to the west; thence to latitude 4° north, to the east northeast; after which the Equatorial current was experienced to latitude 7° south, from which parallel to the latitude 18° south the set of the current was to the east southeast; the next nine degrees, or as far as latitude 27° south, it took a southwest direction, and then an easterly one. The weather was remarkably fine, and the passage considered a short one.

FROM SYDNEY, NEW SOUTH WALES, TO CAPE HORN AND RIO JANEIRO.

Between the 20th of November, 1839, and the 29th of January, 1840.

This passage occupied a period of 70 days, and is to be considered short. The route taken was by Cook's Straits, between the Islands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positions assigned for Islands by Whalers and others
U. S. Ship Relief August 1839
Reported Groups
SEARCH FOR ISLANDS
NORTH PACIFIC OCEAN
by the
U.S.Ex.Ex.
1840
138° Lon. W. of Greenwich

of New Zealand: they were reached by the 1st of December, a distance of 1000 miles, in ten days. For the first half of the passage the winds prevailed from the north and west, and the latter half from the southwest: the currents experienced were strong from the northwest; Cook's Straits were passed through without difficulty, the wind and current being favorable: the lands are high and the shores bold, and no dangers to be apprehended. It would be advisable for a stranger, if he should be late in approaching the Straits, not to attempt them until the reappearance of daylight. There is no particular caution necessary, except to keep the mid-channel, where a vessel would be least affected by the tides, and have all the benefits of the current, if any existed. In case vessels desired to stop, they may seek temporary anchorage in the bays on the north or south: here some supplies can be obtained. Formerly much was to be apprehended from the savage disposition of the natives, but since the large emigration of English, they are friendly and desirous of trading for their productions, which consist of potatoes and hogs.

The Relief's run to Cape Horn was made in 31 days, a distance of 4500 miles. The course was almost a direct one, with a fair wind either on one side or the other all the distance. The first 900 miles after leaving New Zealand, it blew from the north to north northeast; for the next 600 miles, from the southwest and south; then it came out again from the north until they reached longitude 127° west, where they encountered, but for a day, the only head wind during the passage; when it again blew from the southwest or northwest until they reached Cape Horn, passing which they arrived at the latitude of 45° south, in the South Atlantic, where they were met by the northwesterly winds, which compelled them to make a considerable deviation from their course, and retarded their arrival at Rio. At no time of the passage did they enter the southeast Trades; the winds were from the southwest and west, resembling in character a Monsoon. Until within several hundred miles of Cape Horn, they may be said not to have had any current: that which they did meet with was from the northward, but as they approached the Cape, it was found to be 30 miles a day, setting to the east southeast; and after passing the Cape, it set to the northeast and east, to the latitude of 45° south, when it changed to the southwest, southeast, northeast, and west, for the last few days, before their arrival at Rio Janeiro.

This may be said to be the best time of the year to make this passage: no ice was seen, and the long days make it less hazardous to encounter. In some years, during the months of December and January, much ice has been met with, so much so that many of our whale ships have considered it far safer to put back to the northward again,

and wait until it disappeared. The year 1832 was remarkable for the numerous icebergs seen.

The passage by Cape Horn may be at all times considered the best for homeward-bound ships from the coast of New Holland or New Zealand; the track during the summer, to insure steady and favorable winds, is between the latitudes of 45° and 50° south. In the winter months of the southern hemisphere it would be much better to keep near the parallel of 40° south, until approaching the Cape, when a course which would lead for it should be adopted: this will secure better weather and more constant winds.

THE ANTARCTIC CRUISE.

Between the 26th of December, 1839, and the 11th of March, 1840.

Although this does not come within the usual limits of the routes of vessels, yet it may prove of use to some navigators who visit the high southern latitudes, to give the sailing directions.

In navigating towards the Antarctic, vessels should be well found, not only with good sails and rigging, but protected against cold and wet: the temperature, though not very low, is remarkably searching; and, from its being a low temperature, and damp, there is no opportunity to ventilate or dry the vessel except by artificial means. Icebergs are seldom met with south of Australia, until the latitude of 56° south is reached, unless well to the westward of New Holland, where they have been encountered in as low a latitude as 42° south, by vessels making the passage to New South Wales in October and November; but this is unusually far to the northward at this time of the year; later in the year they have been met with off the Cape of Good Hope, where several accidents have happened by vessels coming in contact with them. The prevalence of a current setting to the northeast is the only way in which these masses of ice can be carried to so low a latitude as a few degrees to the southward of the Cape of Good Hope.

On leaving Sydney we had easterly winds, which enabled us to stand to the southward, and favored us for several days, gradually hauling to the northward and eastward. On reaching the latitude of 45° south, the wind came from the north, and northward and westward, accompanied with lightning and thunder, a change of weather, boisterous, misty, and disagreeable, settling into thick fog, attended with a fall of the mercury in both the barometer and thermometer. On the tenth day, we made Macquarie's Island; the westerly winds, which had set in strong, with a northeasterly current, carried us to leeward of that

island. Vessels wishing to visit Macquarie's Island, ought to allow for a northeasterly set of 20 to 30 miles in the 24 hours. The south end of Macquarie's Island we place in latitude 54° 44′ south, and longitude 159° 49′ east: it is within the stormy latitudes. After leaving it we cannot be said to have enjoyed any continuance of fine weather in the higher latitudes, along the Antarctic continent especially, while the wind was in the western quarter; after passing to the west of 160° longitude, instead of northwest and southwest winds, they prevailed from the eastward with better weather: although our hardest gales came from the southeast, arising very suddenly, they were generally preceded by fine weather whilst the wind continued to the northward of east, the barometer falling, while the temperature rose. Easterly winds prevail to the southward of latitude 60° south, but to the north of that parallel, westerly winds, accompanied by fog, snow, sleet, but seldom rain. Heavy cumulus clouds in the southwest indicate wind from that quarter, as they do to the south of Cape Horn; but though boisterous, they are not to be classed as storms. The barometer's range is low, the mean being 29·04 inches; its movements are rapid, frequently a great change occurring within an hour. The wind increases as it rises, and continues for some hours after it has become stationary.

We next passed over the locality of Emerald Isle, assuming its position to be in latitude 57° 15′ south, and longitude 162° 30′ east, but saw nothing which indicated its existence. During the continuance of our cruise of 1500 miles along the Antarctic coast, we were for a large part of the time surrounded by vast numbers of icebergs, as well as having the icy barrier attached to the land to avoid; consequently it became difficult to ascertain if any current existed. The small movement of the ice to and fro, where we had an opportunity of observing it, indicated that the tides were not of much strength. The most unpleasant occurrence in this navigation is the sudden rising of fog frequently when the ship is surrounded in all directions by numbers of these bergs of all sizes and shapes, differing in height as much as they do in length, from 5 feet above the sea surface until they reach that of 220. Those who attempt to navigate among these bergs would do well to observe the rule, never to pass very close to windward of them; the wind is apt to fail at the most critical point, or haul a point or two, and the set of the current is sure to be towards them, involving a vessel in much hazard, as well as creating great anxiety for her safety. So far as the fear of the bottom striking, or the hull coming in contact, there need be no apprehension; the spars would be the first to touch, the iceberg continuing the wall-sided structure to a great depth below the surface. I can only add that there is very great

hazard in navigating along the Antarctic coast during the season of all daylight; how much more so must it be with a part of the time night!

Our return route from the coast of the Antarctic continent in longitude 98° east and 65° south, was made to the northeastward, towards the south of Van Diemen's Land; here we were favored with strong gales from the southwest and west, such as usually prevail between the latitude of 50° and 60° south of New Holland; and from our own experience, as well as the character given of the latitudes in this locality, I am satisfied that this may well be termed a region of storms. I have heard an opinion entertained that a southern passage was the most advisable in leaving Sydney for England; that is, passing to the south of Van Diemen's Land, it has frequently been attempted, and perhaps in a few instances with success, but I am well satisfied that it cannot prove of any advantage to the navigator to take this route: the winds will be found to prevail for the most part from the northwest and southwest, which are boisterous, and accompanied with heavy seas from the same quarter; after visiting the high latitudes, I cannot believe any one could have the hardihood to advise it, let alone to make the attempt. The wear and tear of such a voyage, its length and chances of sustaining damage, in all probability, making a return to port absolutely necessary, are greatly against it: the expenses thereby incurred would be more than sufficient to pay for navigating in the Tropics for months.

On our return we encountered the currents already mentioned, setting to the southward, along the coast of New Holland; which readily accounts for the difference in the length of passage from Sydney to Van Diemen's Land and back. By keeping off from the coast a sufficient distance, the return passage will be much shortened, or, in a small vessel, by hugging the coast, the eddy current may be taken advantage of during the fine season.

FROM SYDNEY TO BAY OF ISLANDS, NEW ZEALAND.

Between the 19th and 30th of March, 1840.

Sydney and the north point of New Zealand lie very nearly in the same latitude; the course is therefore nearly due east. We enjoyed fine weather, smooth seas, and fair winds, and made the run in eleven days. The winds prevailed from the north, and northward and westward. On approaching the island, the wind veered to the southwest, and after getting to the eastward of Cape Otou, became variable. The currents during the passage were from the northwest, until approaching New Zealand, when they came from the southeast. After the month of March, on the coast of New Holland, the winds prevail from the south-

east, when it is difficult to get an offing. The Peacock, in the month of April, experienced light southeast winds for 12 days after she left Sydney, on her passage to the Friendly Islands, at the same time was set by a strong current to the northwest, which carried her within 150 miles of New Caledonia before she could make easting. Her passage to Tongataboo was in consequence greatly retarded, having been 32 days making the distance of 1700 miles. I think it would be preferable if, on leaving Sydney, should the wind be encountered from the eastward, to stand to the southward until sufficiently out of the influence of the coast, or if the wind did not permit that tack to be taken, then beat directly to windward until 100 or 150 miles from the port, rather than pursue the northern route.

FROM BAY OF ISLANDS, NEW ZEALAND, TO TONGATABOO, FRIENDLY ISLANDS.

Between the 6th and 24th of April, 1840.

This passage was made by the Vincennes, Porpoise, and Flying-Fish, in 18 days. On the 6th day we passed over the Rosetta Shoal, without finding it. On the 8th, we sighted Raoul or Sunday Island, the most northern of the Kermadec Islands. The winds were variable, which was also the case with the currents. These islands, situated in latitude 30° south, exert considerable influence on the course of the Trades, and produce calms in their neighborhood, particularly to the westward. The passage might have been performed in less time, if we had gone to the eastward of the Kermadec Islands; by which route I am of opinion we should have found the southeast Trades in a higher latitude. In sailing to the Friendly Group, Eooa is the best to sight: it is high, and may be seen at a considerable distance. At some seasons currents are said to prevail off these islands, setting to the westward.

On this passage, Vasquez Island was searched for, in latitude 24° 44′ south, and longitude 174° 25′ west, but without success.

Intending to enter the harbor of Tongataboo, a vessel should be off its eastern entrance, the Astrolabe Gut, at an early hour of the day, to take advantage of the sea-breeze or Trade which then usually sets in. The Gut is 9 miles long, and contracts from 2 miles at its mouth to a quarter of a mile in width at its western terminus, and is difficult to navigate unless with a fair wind; coral reefs border each side, and no anchorage can be had until the western end is reached, where the island and reef of Magonha separate it from the harbor. The channels on either side of this island may be taken; though narrow, they are perfectly safe, and after passing through, safe anchorage is found in a

spacious harbor, well protected by the surrounding land and the outlying reefs, which are of great extent. The anchorage near the island of Pangaimotu is the best, but that off the town of Nukualofa is usually preferred, being more convenient for obtaining supplies. The shore-reef is of great extent, bare at low water, making it extremely difficult to land in boats, so that intercourse with the shore is generally limited to the time of high water.

This group of islands is frequently visited by severe hurricanes, that do much damage; these occur in the months of November, December, January, February, and March; it is then that the anchorage in Mariner's Bay is much exposed, both to sea and wind; the former is said to beat at times very heavy on the shore: it may be as well to avoid making a visit to these islands during those months. Myriads of mosquitoes are the greatest annoyances in this bay; they infest all parts of the ship, and render rest absolutely out of the question; the only way to free oneself from them is by anchoring some three miles from the land. On the beach to the south of Pangaimotu the seine may be drawn, and at times with great success.

TONGATABOO AND THE FEEJEE ISLANDS.

May, 1840.

We were two days on this passage. The Squadron went to sea through the reefs by the north channel, and with a favorable wind sailed past the islands of Honga Tonga and Honga Hapai, steering to sight Turtle Island, after which, the course was changed to make the island of Ongea, one of the eastern group of the Feejee Islands. This is one of the best islands to sight, if bound into any of the harbors of the Feejee Group from the southeast. It forms the eastern side of the Fulanga Passage, which may be passed through, but it would be advisable to go to the southward of Fulanga and steer for Moala, running close to Kambara. When to the westward of Kambara, if overtaken by night, there is plenty of sea-room, to await daylight; a vessel can then pursue her course towards her port with safety.

The fine season in the Viti or Feejee Group is from April till November, during which time the winds generally prevail from the east northeast to southeast; they sometimes blow fresh, but usually a moderate Trade prevails, increasing toward the afternoon, and moderating towards night, and continuing during the night hours light and calm. In the harbors and along the larger islands, a gentle land breeze is frequently felt a short time before and after daylight, but is never of long duration, yet it affords facilities of passing outside of the reefs, which obviates

much anxiety, as well as the risk of accident. In navigating among the islands, the tides should claim particular attention: the course of the flood and ebb are shown on the chart; but there are times of tide in which the current is often found to set stronger in some places than in others, from the water being forced through the narrow passages between the reefs. Those navigating within the reefs can very readily perceive when this is likely to be the case; after the reefs become visible, the current through the passages is much stronger, and at times it flows with the rapidity of a sluice; it is not advisable to attempt to pass. Against this current it is next to impossible to strive, except with a very strong wind.

From November to March, northerly winds for the most part prevail, which blow from the northwest with great violence. The heaviest gales come from this quarter, and prevail during February and March. In these months the weather is very wet and unpleasant. At this time of year, vessels visiting this group would do well to seek those harbors that are the best protected and least exposed to the northwest. If bad weather occurs between April and November, the wind will prevail from the east to southeast; it blows very strong, but is not accompanied by rain, although a mist prevails that renders everything obscure, which generally continues for three or four days, but there are no sudden changes of wind, or tornado storms, as is experienced in the bad season.

The progress of these islands in civilization since our visit has been such as to make it unnecessary to offer any remarks upon the intercourse with the natives, their character, customs, &c.; these have been fully detailed in the third volume of the Narrative of the Exploring Expedition,—and it is presumed that no navigator will visit this interesting group without possessing that work, which contains a full account of our intercourse with them, and which, it is believed, will afford an accurate view of the facilities as well as the difficulties which are to be expected from intercourse with them. The passages into the Group will be described as given in the hydrography of the Exploring Expedition.

FULANGA PASSAGE.

The Fulanga Passage is the most southern. It is bounded on the east by the islands of Ongea, Angasa, Namuka, and Olenea; on the west by Fulanga, Moramba, Kambara, Enkaba, and Tubanaielli: the course through is north 35° west. The two Ongea Islands are suitable to make for a land-fall, having a care to avoid the coral sand-bank of Nuga Ongea, which lies to the southeast of the Ongeas; those intend-

ing to enter the Feejee Group at its southeastern extremity would do well to pursue this course, especially if intending to touch at Lakemba, which island affords the best point to gain information from the missionaries, as to the condition of the group. I look upon it as necessary for all vessels upon a trading voyage to obtain a correct knowledge of the political state of the group. There a friendly reception will always be met with, and vessels may procure either a foreign or native pilot.

On arriving off Ongea, and with daylight, I would advise this passage being taken. The distance to Lakemba is but 60 miles; the passage through it is 30 miles in length. The wind will generally draw to the northwest. When the island of Namuka bears east, and that of Olenea to the eastward of north, a north course may be steered for Lakemba. Due regard must be paid to an easterly set, which is seldom less than half a mile per hour. Should the weather on arrival off Ongea prove bad, or be doubtful in its appearance, and having no intentions of stopping at Lakemba, I would recommend sailing to the southward of the island of Fulanga, and not enter the passage, but steer a course north by west, which will lead 10 miles to windward of the Tova Reef, distant 55 miles from Fulanga. If however, apprehensions should be entertained of passing to windward of so dangerous a shoal at night, I would then suggest a west northwest course for the island of Moala, distant 75 miles.

The winds will be found to prevail from the east northeast to east southeast, generally from the former, and very seldom from the latter. When the wind has been blowing a strong Trade for several days, and has become squally, it will continue from 30 to 40 hours; after this it will change to variable, with rain, shifting to the northwest for a day, then hauling round again to the eastward, with fine weather.

ONEATA PASSAGE.

The Oneata Passage may be recommended if the weather should be fine. It lies between Oneata on the north, and Motha on the south. To enter it, steer a direct west course for Oneata Island, which is high and remarkable; Motha and it will be seen long before the reefs are discovered. By keeping on the northern side of the passage, the Ickulaka Reef, which lies directly north of Motha, will be avoided. The Oneata is the shortest of the passages, and may be considered the best. Its length is 15 miles, and its width 10 miles; this, however, is partly taken up by the reefs of Ickulaka. If the passage should be reached near night-fall, and the weather prove bad, it would be advisable to run for a harbor within the reef of Oneata; there is no difficulty

in entering while daylight lasts, and the anchorage under Observatory Isle will be found safe. The break in the reef lies north 67° east from the isle. If the weather is fine, after passing Oneata, Lakemba will be in sight, when a course may be steered to round the reefs of the two Aivas, or, with the intention of passing into the group, steer direct for Vanua Vatu, thence for Nairai through the Sea of Goro.

LAKEMBA PASSAGE.

The Lakemba Passage should not be attempted except in fine weather and by daylight. The reefs will be fallen in with before the islands are seen. The first land made in approaching it from the east will be the island of Tabutha, with its conical cap. The outlying reefs to the east are distant from it 15 miles; much danger may therefore be incurred before a vessel gets sight of it. If a good look-out is kept from aloft, these reefs will be seen in time to avoid, as the sea constantly breaks over them, which permits their being distinguished at from two to three miles' distance. Reid's Isles lie on the south side of this channel, situated in the Latte Reef; if these should be made to the westward, no time ought to be lost in hauling up to pass to the northward of them, and after they bear south, the island of Naiau should be steered for. The direct course through this channel is southwest. It is 46 miles in length and 16 miles at its narrowest part. Though obstructed by outlying reefs of great extent, yet, after these are passed, there is a clear and open sea for vessels to work in, and the islands of Lakemba and Naiau are good marks, being careful not to bring the island of Lakemba to bear to the west of southwest, on which bearing the northern edge of the Bocatatanoa Reef lies. The wind usually permits a vessel to stand through this passage.

NANUKU PASSAGE.

The Nanuku Passage is the most northern in the Eastern Group. In fine weather it may be approached without danger. The course through this channel is southwest half west. Vessels desirous of passing through it, should endeavor to make the Island of Nanuku. After they have sighted it, the passage will be open, and by steering a southwest course, they will be led into the Sea of Goro, where they will find plenty of room to encounter bad weather. If vessels should be at the entrance of this passage towards nightfall, without having made either Nanuku or Yalangalala islands, I would strongly urge them to continue their course, if they are sure of their latitude, as much the safest; by so doing they will avoid the doubt as to their situation, which a few

hours' lying-by would produce, from drift by current; indeed, it is desirable to pursue this course also in making the reefs at the mouth of the Lakemba Passage. It must be constantly borne in mind, when approaching this group, that the reefs, in most cases, and particularly those of great extent, and most dangerous, extend the greatest distance on the windward or eastern side of the islands, and therefore, by getting on the western side, dangers are not only avoided, but smooth water may be found under the lee of the islands.

Vessels entering through the Nanuku Passage and bound for Somu-somu, can haul up to the north northwest, to pass between the reef of Lauthala and Nanuku, and thence round the north end of Vuna, into the Strait of Somu-somu. This course I deem preferable to passing through Tasman's Strait. Another and a safe route is to stand on to the southwest, and pass round the south end of Vuna into the Strait of Somu-somu, as the Trades will be retained and the harbors of Somu-somu reached much sooner. If not disposed to proceed beyond Lauthala, advantage may be taken of the harbor at the junction of Kamia and Lauthala Islands, which is well protected by the reef, and easy of access, from the absence of reef to the eastward of Matangi.

These Passages are all suitable for a vessel bound to or through this group, sailing from east to west. I have not imagined that any navigator would have the hardihood to attempt to pass in a contrary direction, surrounded as he would be by so many dangers, and which he had no necessity for encountering, with a certainty of adverse winds.

KANTAVU PASSAGE.

The channel lying between the island of Kantavu on the south, and 'Mbenga, Viti Levu, and Vatulele, with their reefs, on the north, I have called the Kantavu Passage. At the eastern end, in a northwest direction from the north point of the Astrolabe Reef to that of 'Mbenga, it is 24 miles wide, and at its western end, between the west point of Kantavu and Vatulele, it is 30 miles; it is 40 miles in length, — the direct course through is east northeast and west southwest; it affords ample room for a vessel to work in. It must be borne in mind, when navigating through it, that the tides are strong, and that the flood sets to the northward and westward, while the ebb runs with some velocity to the southward and eastward: during the night there is generally little or no wind, and a vessel may consequently be subjected to the full action of the tides. In order to enable whaling ships to obtain their longitude correctly in passing this group, I carried meridian distances from the Observatory at Ovolau, to the peaks; their true

positions, therefore, have been ascertained with much accuracy through azimuthal bearings and distances determined by triangulation.

The latitude of the Peak of Kantavu is 19° 05′ south, and its longitude 177° 58′ east. 'Mbenga Peak is in latitude 18° 22′ 30″ south, and longitude 178° 07′ 30″ east. The southeast point of Vatulele is in latitude 18° 37′ 30″ south, and longitude 177° 39′ 30″ east. Navula Point (west point of Viti Levu) is in latitude 18° south, longitude 177° 12′ 30″ east.

MOTURIKI PASSAGE.

The Moturiki Passage is 4 miles in length, by three-fourths of a mile wide in its narrowest part, between the island of Thangala on the north, and those of Leluvia, Angasau, and Tombu, with their reefs, on the south. This last is situated at its entrance, near the point of the great reef of Viti Levu, that trends towards Kamba Point. These small islands and reefs form the portals to the Bay of Ambau; they are each about a mile in circumference, and covered with foliage, which gives them a pretty appearance. In the Passage there are no soundings, but under the western side of the island of Leluvia, a vessel may anchor in 10 fathoms water, sandy bottom. The mark for sailing through the Moturiki Passage is Rich's Peak, on Viti Levu, which bring to bear due west. Before reaching Leluvia, on the south side, there are some small coral patches; it is best to avoid these by keeping on the north side. The tides run strong through this Passage; the flood flows in, and the ebb out; the latter continues 8 or 9 hours out of the 12. Anchorage may be had under Thangala or Moturiki, by passing through the entrances in the north reef.

SOUTH ENTRANCE AND ROUND ISLAND PASSAGE.

I have already described the entrance into the Viti Group, by the several passages through the eastern islands; it now remains to mention that from the south, which may be preferred by many intending to anchor at Ovolau, or pass through the reefs to some of the ports and anchorages in the larger islands, within the Sea of Viti.

In the approach from the south, the best island to sight is Matuku; it lies to the southward of all, is high, and may be seen a long distance in clear weather; a north northwest course, after coming up with it, will take a vessel to Ovolau, 100 miles distant. There are no dangers, excepting the reef of Mumbolithe, on this route; it lies to windward of the course, but care should be taken to avoid it. The high island of Angau, off which this reef lies, will be sighted on the starboard bow,

and when the centre of it bears to the eastward of north, this reef will be passed. On coming up with Ovolau, with a fresh Trade Wind and favorable tide, it is necessary to shorten sail, otherwise the narrow south entrance to the harbor of Levuka may be passed, and oblige a vessel to seek the north entrance, and beat up to the anchorage off the the village. In the forenoon the wind is generally light and variable.

In taking a departure from the Viti Group, two routes present themselves which may be followed, — by the southern entrance and the Round Island Passage—according as it may be the desire of the navigator to proceed to the southward or westward. If the former, the best course is to pass into the Straits of Ovolau, and beat to windward until the reefs off Kamba Point can be cleared, then either to pass to the eastward of the island of Kantavu, or through the Kantavu Passage to the westward; by this route a vessel will gain an offing much sooner than by any other. The departure by the Round Island Passage requires daylight; it is distant from Ovolau 100 miles; the course is about northwest by west. In resolving to take this route there should be a commanding breeze, the weather fine, and an early departure made, in order to secure daylight. The first course after clearing the harbor is to steer for the island of Vitimera, which lies some 30 miles west from Ovolau, and thence direct for Awakalo or Round Island. There are no shoals in this route but what are visible, and by proper precaution in stationing look-outs, these can be seen and avoided. In the morning, when the sun is to the east, is the best time to pass out; by noon these reefs will all be passed, and if care is taken to avoid being set by the tide to the northward, there is no danger to be apprehended. After passing Round Island, all dangers are at an end, and an offing to the westward is soon reached. For further particulars respecting this group, I must refer to the Charts and the Hydrography.

FROM THE FEEJEE GROUP TO THE HAWAIIAN ISLANDS.

Between the 14th of August and 24th of September, 1840.

As this passage was made by the vessels of the Squadron singly, following totally separate routes, and crossing the Equator in different longitudes, it affords information tending to show the best route to take when bound from the Feejee Group to the northern hemisphere, during the months of August and September.

On the 14th of August, the Vincennes, Peacock, Porpoise, and Flying-Fish, left the harbor of Muthuata by the Malu Passage, on the north side of the Island of Vanua Levu; and on getting clear of the reefs, the Porpoise was ordered to visit again the eastern portion of the group, while the Flying-Fish was sent to run along the great

sea-reef, to complete some minor examinations. This separation led to the diversity of routes followed in proceeding to the northward.

The Vincennes and Peacock also parted company the second day out: the former stood to the northward, on the meridian of 178°, with the southeast Trades, which were carried to the latitude of 8° south, when the wind hauled to east northeast, with a long swell from the northward and eastward. The wind had been previously found to veer several points to the northward toward night, and generally continued until morning, when it would veer to the southward again. This obliged us to make northing too fast. On the wind's hauling more to the southward, I determined to make easting instead of running with the wind free to the north. The winds were very light. On the seventh day out, we made an island, which we supposed to be the Kemiss or Gardener's Island of former navigators, and passed the day on it making observations. Here we found the flood setting strong to the northward, and the rise of the tide was 3½ feet, which nearly overflows the island. The next day we discovered McKean's Island, in nearly the same longitude, but a degree north of Kemiss; the winds were quite light, with some rain, which was succeeded by dark, cloudy weather, and showers, with light breezes from the westward. Under these circumstances, I steered to the eastward for the Phœnix Group. After copious rains (5·2 inches), the weather cleared up, the wind returned again to its old quarter, southeast. We had heavy rolling seas from the southward, and a current of half a mile, setting south quarter west.

We passed 10 days in examining the Phœnix Group; three of the five islands of which it is composed were surveyed. They are situated between latitude 5° south and the Equator; and between longitudes 168° and 173° west.

The winds were very variable, as well as the weather, and the currents vacillating: some days equal to 30 miles to the west, again to the southwest, and then none at all. It was not until the 4th of September that we crossed the Equator, in longitude 168° west. The day before crossing, the weather was delightful, with a strong breeze from the east; we then stood to the northward, keeping the ship a good full by the wind, which now veered from southeast to east southeast, with occasional squalls and rain. This weather continued until we entered the northeast Trades, between the latitudes of 9° and 10° north. We were from this time (11th of September) until the 19th, beating up for the Hawaiian Islands, taking every advantage of the variation of wind to make the most easting, when we made the Island of Kauai, and two days afterwards anchored off the town of Honolulu, Oahu: making the

passage in 41 days, including the ten days' detention in the explorations of the Phœnix Group.

The Peacock's course was different. Captain Hudson determined to keep at once to the northward, and crossed the Equator in longitude 174° 30′ west, about 350 miles to the west of where it was cut by the Vincennes. The Peacock passed over the locality of the shoals reported by Captain Swain, of Nantucket, as lying near Solitary Isle, of Arrowsmith's charts, but saw nothing of them. She experienced the same kind of baffling and light winds as described by the Vincennes, but they were somewhat more to the northward and eastward. The weather was fine, but warm. In latitude 2° south, the Peacock experienced the same heavy swell from the eastward as the Vincennes, which occasioned the ship to roll excessively,—the surface of the ocean being as smooth as a mirror. It was followed by the wind from the west and southwest, and after rain, again returned to the eastern quarter, inclining to southeast, though baffling and squally, which continued until they had reached the latitude of 5° north; the atmosphere being hazy and the weather sultry. Here they encountered the northeast Trades, exceedingly variable in direction, changing from northeast to east, with frequent squalls and rain. Between the latitudes of 6° and 7° north, they made a tack for several days to the southward and eastward, and were favored by the easterly current. The winds were found too baffling and uncertain to make much progress in beating to windward; besides, the ship was light, and not in a condition to hold a wind; notwithstanding, it is evident that she made much progress to the east, which could not have been done if a strong easterly current had not prevailed.

On the parallel of 10° north, they had fairly entered the northeast Trades, and made the best of their way to the northward, arriving at Oahu on the 1st of October, making the passage in 50 days. Captain Hudson found the northeast Trades very strong and squally, much more so than we experienced them. The lightness of his vessel may account for the difference in the passages, but I am also inclined to believe that there is something in crossing the Equator in a more easterly longitude, thereby preserving the southeasterly winds longer, and being less subject to calms. The southeast wind, during the Porpoise's passage from the Samoan Group, while it lasted, enabled her to make considerably more easting, crossing the Equator in 165° 30′ west; she also kept a fresh southeast wind to latitude 5° north, having crossed the Equator on the tenth day, and making the passage from the Samoan Group in 27 days; being only 17 days from the line, while the Vincennes and Peacock were respectively 26 and 33. I

would not assert that this fully establishes the fact of its being a better route ; for the Samoan Group lies some 500 miles to the eastward of where the two ships crossed the same parallel. This easting may be considered a full equivalent for the difference in length of the passages; but I feel satisfied, after making a careful examination of the whole route, that it is also due to the prevalence of more favorable and stronger winds.

The Flying-Fish crossed the Equator in the same longitude as the Porpoise. Passing to the eastward of all the small groups, she preserved the southeast Trades, and made the passage in 33 days: this length of passage cannot be compared with that of the other vessels, the schooner being well adapted for plying to windward, and only shows the prevalence of fresh southeast winds.

The weather, so far as respects its general character, appears to have been nearly similar with all. The currents on the western track were more variable in direction than those to the eastward, in the same latitudes, and of greater velocity. All experienced the northeasterly set of the current between 4° and 9° of north latitude. After entering the northeast Trades, they encountered a strong westerly set, averaging 15 miles in 24 hours, and this continued to the latitude of the Hawaiian Islands.

It will now be apparent that there is no necessity for vessels bound to the northward and eastward across the Pacific ocean, to make for the northern variables, as has heretofore been the practice, — thus making a very circuitous course and occupying a much greater portion of time, besides subjecting themselves to encounter much bad weather. This, however, is not to be understood as applying to vessels to the westward of 180° longitude: they ought to make the shortest possible stay within the Trades; and if this course is determined upon, they should steer due north, without regard to making easting, until they have fully entered the variables. It is, however, at times very doubtful where they will encounter them ; and as far as our experience goes, and that of other navigators whom I have consulted, they ought not to be expected short of 27° to 30° of north latitude, to which parallel the Trades often reach. The great difficulty seems to be, with many, that on the first wind from the west being encountered, they are induced to believe that it will prove constant, when nine times in ten they will be deceived. The Hawaiian Islands are fully treated of in the Hydrography, and the Charts of the group and harbors will be found in the Atlas of the Expedition.

FROM THE HAWAIIAN ISLANDS TO THE COLUMBIA RIVER AND STRAITS OF FUCA, OREGON.

Between the 6th of April and the 1st of May, 1841.

The remarks which follow are applicable to any part of the North-west Coast, so far as general directions for sailing towards that coast are concerned. The passages made by the Vincennes and Peacock, the one in April, the other in July, show the winds during those seasons on the above route, and the time when it is most favorable to visit that coast. That different winds as well as currents are met with, is clearly shown by the tracks of the two ships on the General Chart of the Pacific.

The Vincennes left Oahu on the 6th of April, and passed between Oahu and Kauai. For the first 8 days the wind was from north by east, the weather being disagreeable and cloudy. On the 14th, we had reached the latitude of 26° 30′ north, longitude 160° west, and had passed through the zone of calms (then about 300 miles from our port of departure), when the wind hauled to the southeast; with but a few hours' exception, the Vincennes carried this southeast wind to the coast: it was quite strong, attended with much haze and fog. In latitude 28° 30′ north, we had the report of land; but it proved a false alarm. Many navigators have looked for land in the space comprised within the latitudes of 33° and 43° north, and longitudes 140° and 150° west, as yet unsuccessfully: all have been satisfied that the appearances of land are frequent and not to be mistaken, — land-birds in particular being numerous; this part of the ocean, from the low temperature of the water and the warm air blowing over it, is nearly always enveloped in fog and haze, rendering its examination exceedingly difficult; consequently rocks or even small islands may exist which have not yet been discovered.

In passing over this space, I endeavored to take such a course as would lead clear of the tracks of navigators who had preceded us. This part of the north Pacific should be examined in the winter season, when it is probable these fogs do not exist to such a degree as they are found the rest of the year. The extent of these fogs, and the track of vessels which have passed through them, are given in the annexed map.

The quantities of villella that were met with exceeds belief. The sea may be said to be covered with them, having the appearance of a vast sheet of water spread over with cinders. What seems remarkable, the position of these zoophytes has not changed since they were met by Vancouver fifty years before. This seems to me to offer a strong

proof that, having been brought by currents from the north and deposited here, they are retained by the absence of all current within these limits. There was no perceptible current experienced as we crossed this space of ocean; but to the northward of it we experienced a very strong one, setting to the southeast some 35 miles a day, from 150 to 700 miles from the coast. The temperature of the water, also, indicated a southerly current.

Notwithstanding the detention we met with in passing through the calm latitudes, we made the passage in 22 days to the mouth of the Columbia River, which was unusually short. It is well here to state that the southeast wind is not to be regarded as the regular one of this coast: seldom blowing except during the winter and spring months. The southerly currents experienced by the Vincennes (as shown on the Pacific Chart), on approaching the coast at this season of the year, may be expected, and no doubt prevail during the other spring months with equal force.

The Peacock made the passage in June and July. She did not get through the calms until reaching latitude 33° north, in longitude 157° west. The winds afterwards were from the east, and carried her to the latitude of 44° north before she was enabled to make easting; then she encountered the prevalent winds from the west and southwest. Instead of the current which the Vincennes experienced, it was found to set in an opposite direction, though not strong. Her passage was made in 27 days, although the route was farther to the westward than that of the Vincennes. The villella were met with in latitude 40° north, longitude 157° west, and were lost sight of in latitude 43° north, longitude 155° west. The limits of this mollusca may therefore be said to extend nearly through 18° of longitude on the latitude of 40° north,—and to cover a space equal to 800 miles in length, and 180 miles wide.

From these two passages, it would appear that very different routes are to be pursued at different seasons. In the spring, the winds will be found, after having passed beyond the calms, more from the southeast than in summer; consequently, vessels should hold more to the east, and cross the calms in the most eastern longitude, and as quickly as possible; it likewise shows that the calms are of less width, though more difficult to pass through, in the spring. As was proved, the error committed in the Vincennes was in not keeping by the wind, and therefore too far to the west, thus falling under the lee or influence of the currents of air in the neighborhood of the Hawaiian Group, which detained us. The information received from those who were supposed to be well informed upon the subject, induced me to take this course,

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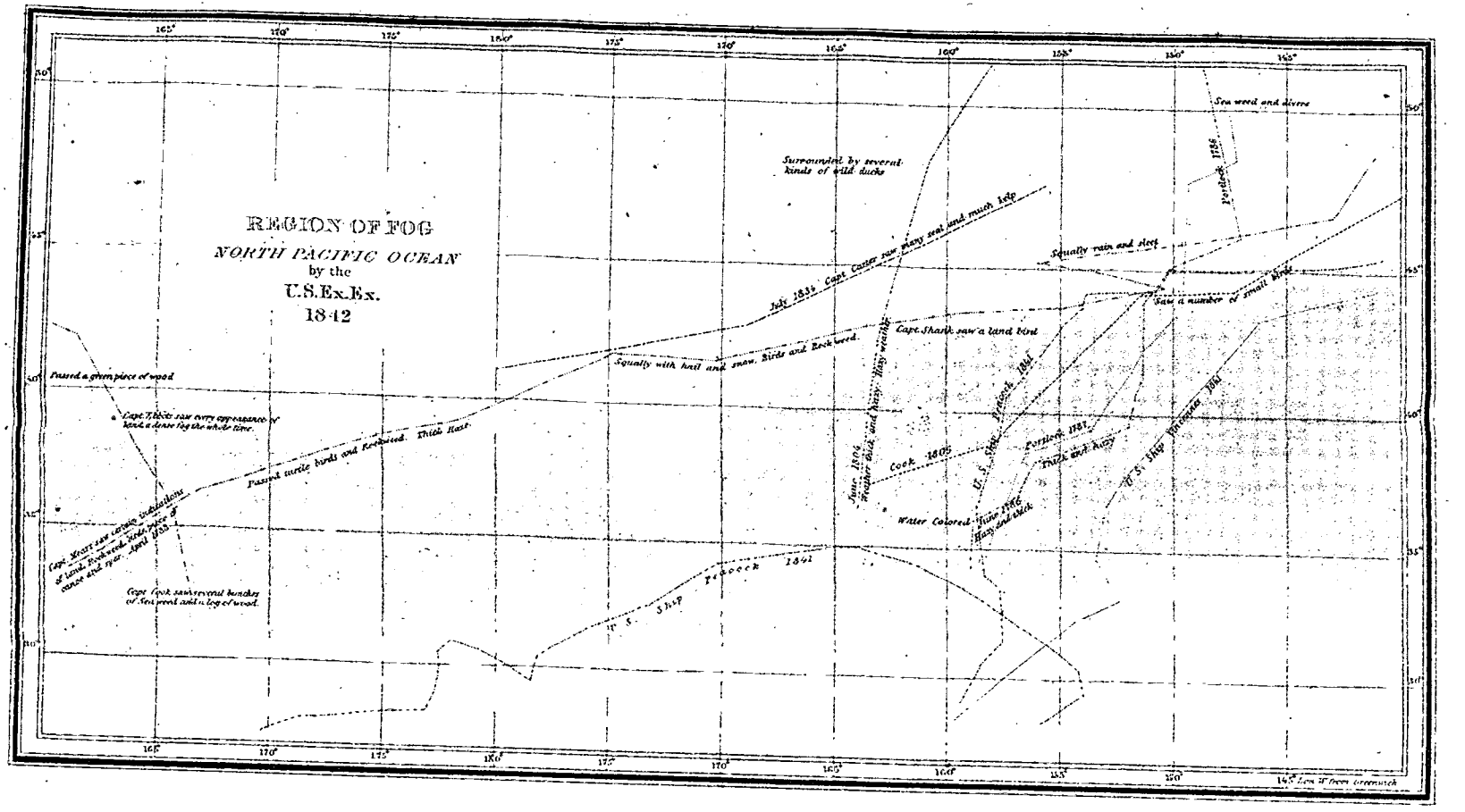
expecting to meet the northwest and westerly winds in a low latitude, and consequently be in a situation to take full advantage of them. The plan I should have adopted was, to stand directly to the north, or to the northward and eastward, and thus make a more easterly route. This the Peacock did, and the first part of her passage was made in much less time. I would, in making the passage again, in the spring or summer, expect to have east and southeast winds to latitude 40°, making as direct a course as they would permit towards the part of the coast for which I was bound. All vessels may expect to meet with fogs and hazy atmosphere between latitudes 33° and 40° This space might be very truly called the region of fog, the temperature of the water decreasing some 15°; and what perhaps is more remarkable, on a near approach to the coast, it again rises.

The navigation from the Columbia River to the Straits of Fuca requires some care. There is a current setting upon the coast, of some force, during the spring months. In our passage we experienced it, and came very nearly meeting with a serious accident off Destruction Islet, near Cape Grenville. Fogs usually prevail until a late hour in the morning, and care should be taken to keep a good offing. The distance from shore may be readily ascertained by the soundings, and it would be advisable, in unsettled weather, or fog, not to approach nearer than 90 fathoms water, which will be found at the distance of 35 miles from the coast, muddy bottom. If, in standing along the coast, the water should become of a light green, and the waterfowl be numerous, no time should be lost in changing the course: it is not safe to approach the coast nearer, as there are many outlying rocks on which a vessel may strike. This is particularly the case in the neighborhood of Cape Flattery, near the entrance to the Str its of Fuca. The coast runs a little to the westward of north; but it may with proper precautions be considered safe, as the prevailing gales enable a vessel to make an offing, either on one tack or the other, and the Straits of Fuca are at all times under the lee, with good harbors and anchorages; these may be entered without apprehension. The charts published in the Atlas, as well as the volume on Hydrography, are referred to, where full directions will be found.

FROM THE STRAITS OF FUCA, OREGON, TO SAN FRANCISCO, CALIFORNIA.

Between the 3d and 14th of August, 1841.

This route is along the line of the coast of Oregon, where the prevailing winds in summer are from the southwest to northwest; generally to the southward of west before meridian, and after that time to


REGION OF FOG
NORTH PACIFIC OCEAN
by the
U.S.Ex.Ex.
1842
Surrounded by several kinds of wild ducks
Sea weed and divers
Yorktown 1788
July 1834 Capt Cutter saw many seal and much kelp
Squally rain and sleet
Saw a number of small birds
Capt. Shank saw a land bird
Squally with hail and snow. Birds and Rockweed.
Passed a green piece of wood
Capt Thicke saw every appearance of land a dense fog the whole time
Passed turtle birds and Rockweed. Thick Hazy
Capt. Scott saw various indications of Land. Rockweed, birds, piece of canoe and tree. April 1838
Capt Cook saw several bunches of Sea weed and a log of wood.
June 1804 Prophet Bird and hazy. Hazy weather
Cook 1805
U.S. Ship Peacock 1841
Portland 1781
Thick and hazy
U.S. Ship Porpoise 1841
Water Colored. June 1846 Hazy and thick
U. S. Ship Peacock 1841
165° 170° 175° 180° 175° 170° 165° 160° 155° 150° 145° from Greenwich
50° 45° 40° 35°

the northward: the distance is over 10° of latitude. It is advisable, in sailing coastwise, to keep off shore from 60 to 100 miles. The winds will be found much more constant, and there will not be the same liability to fog, and the currents, if any, will be favorable, when bound to the southward: excepting in the early spring months, there is but little current. From five to seven days will be the average passage. In approaching the harbor of San Francisco, it is advisable to make the Punta de los Reyes, which may be considered the northern point of land, forming the Bay of San Francisco. By this course vessels will avoid the Farallone Islands and Rocks, which lie off from the land 22 miles. The passage is quite safe on either side of these rocks, and they can be closely approached; but if at night, give them a good berth.

The return passage to the northward is more difficult in the fine season, as the prevailing winds and the trending of the coast make it necessary to beat nearly the whole distance; but there are times when a vessel may carry the southwest wind from the one port to the other. On leaving the Bay of San Francisco an offing should be obtained as soon as possible, from 100 to 150 miles, when any slant that may offer could be taken advantage of, and the passage made in the shortest time. The directions for sailing into San Francisco are also given in the volume on Hydrography.

FROM SAN FRANCISCO TO THE HAWAIIAN ISLANDS.

Between the 1st and the 15th of November, 1841.

This passage was made in 15 days. On leaving the coast, we were favored with a fresh wind from the northward and westward, accompanied by a dense fog for 150 miles from the coast. We steered a southwest course, to enter the Trade Winds as soon as possible. As we made southing, the wind veered to the northward; and to the northward and eastward, when in latitude 26° north, and longitude 132° west, with the usual appearances of the Trade Winds. In latitude 20° north, it veered more to the eastward, and we kept off on a west by south course. The weather was delightful, with a long and regular sea from the eastward. We passed to the west nearly on that parallel until up with the Hawaiian Islands, when we stood to the south, and entered the Pailolo Passage between Maui and Molokai. This passage is safe, and affords, I think, the best route to the Island of Oahu; if belated, a vessel may lie on and off to the westward of Molokai at night, and reach Oahu in time to enter the harbor by early dawn, when a pilot can be obtained. If a vessel is of small burthen, or light draft of water, there is no difficulty in running into the harbor without one,

sufficient way being preserved on the vessel to pass within the buoy. The amount of current experienced during this passage was 56 miles, south 71° west.

Some would probably prefer the direct course from the coast to the Hawaiian Islands. I am satisfied there is little to be gained by it; and I should prefer taking the route which we passed over, getting into the Trades as soon as possible, and after entering them, steering a direct course to the west, for the windward islands, taking care, however, to pass to windward or to the northward of those lying east, and thus avoid being becalmed under them. I do not think it necessary to point out any particular directions for making this passage at other seasons, as they vary but little; the prevailing winds being those we experienced, when an offing from the coast is obtained.

FROM THE HAWAIIAN ISLANDS TO MANILLA AND SINGAPORE.

Between the 1st of December, 1841, and the 14th of January, 1842.

This route is much frequented in all seasons. In the months of December and January, the passage from the Hawaiian Islands to the entrance of the China Sea took us 41 days. As part of this time, however, was occupied in searching for islands and reefs, and as we were obliged to deviate from the direct course for that purpose, it is not a good criterion of the usual time, for I was not intent upon merely making a quick passage; many delays occurring from the necessity of shortening sail and lying to during the nights, in order to avoid passing over parts of the ocean without examination; we also approached several degrees nearer the Equator in our course, where the winds were not so steady, nor so fresh.

I would recommend vessels bound to the west to keep on the parallel of about 18° north latitude, where the Trades will be found stronger and more constant. This was satisfactorily proved when we hauled up to regain a higher latitude, in our search for Wake's Island; which we discovered in latitude 19° 15′ north, and longitude 166° 30′ east. Another reason that may be assigned for keeping on this parallel is, the influence of the westerly current, which is about a half mile per hour. I would not advise making Wake's Island on this passage: it is low and at night dangerous. Its latitude being now well established, there is no difficulty in passing it safely. Wake's Reef also is in this range: its position is said to be in longitude 173° 45′ east, and in latitude 17° 54′ north. I am very much inclined to the belief that it is one and the same with the island, from the exploration we made of it; it

appeared at times to be submerged, which would give it the appearance of a reef.

After the extensive searches we made on this route towards the Marianne Islands, I feel confident there are no dangers which lie in the track of vessels. The positions assigned several islands we found to be erroneous, and passed directly over the place occupied on the charts by Halcyon and Folger's Islands, and saw nothing whatever of them.

From the Hawaiian to the Marianne Islands we experienced a current setting north 68° west, 300 miles, which gives an average of a westerly current of 10 miles per day. The Marianne Islands lie north and south. Vessels generally pass to the northward of Grigan, and between it and Assumption; but I think, if there is no necessity to sight them, that a quicker passage may be made by keeping a degree or two farther to the north, as the winds are undoubtedly more or less influenced by the high land of this group. In our route we went between Assumption and Grigan, and over the position assigned the Mangs by Freycinet. It is not a little singular that the position of these rocks has been laid down to the south, when in truth they lie to the north of Assumption; and that this error has crept into the work of one so generally accurate as the above celebrated navigator. As far as I have examined and made search for them, there are no rocks or shoals existing south of Assumption, and between that island and Grigan, and I am quite certain the Mangs have been erroneously placed.

We were 11 days from the Ladrones to the Bashee Islands: this was in the first part of January. We found the winds variable, generally from the southward, but veering several points, with frequent squalls of rain — what would be termed unsettled weather, and destitute of any resemblance to the Trade Winds — until we approached within a short distance of the Bashee Islands; then we took the northeast Monsoon. In reflecting upon the cause of the variable winds and absence or interruption of the Trades on the route between the Ladrones and the China Sea, it appeared to me difficult to be accounted for, unless it is owing to the prevalence of a southwest Monsoon along the parallels lying between the Marianne and Philippine Islands, and which on the parallel of 19° encounters and interrupts the northeast Trades.

Our route to Manilla, along the west coast of Luzon, was made without difficulty, although somewhat delayed by light winds. The entrance to the Bay of Manilla is often tedious. The channel on the north side of the Island of Corregidor is the best, the winds being more regular and stronger. I made a mistake in beating up in the south channel;

which, though having more space to beat in, I am satisfied is not so good as the north, particularly as great advantage is to be derived from the tide, which sets strongly through the latter. The "inbat" or sea breeze generally prevails in the afternoon, or from 11 A. M. until after sunset.

Navigators may know before they open the Bay of Manilla, whether the northeast wind prevails strong: with it a misty cloud is seen to form an arch to the southwest; if this is not observed, there will be a sea-breeze in the after part of the day.

A vessel may anchor anywhere in the bay. There are some shoal places, but they do not lie in the track of vessels entering or departing. The anchorage off the city of Manilla is safe, except during the season of the typhoons. These sometimes are experienced at Manilla, and do great damage. From the extent of the bay, vessels are exposed to the full violence of the wind and sea, and until within a few years they have never attempted to ride them out. The port of Cavite, which lies on the south side, between Manilla and the entrance or Island of Corregidor, is quite safe. It is there that the Manilla gunboats and galley are stationed, and the government has a dock-yard and some means to make repairs. In the event of a vessel receiving damage, she may find facilities for undergoing repairs there, but it very much depends upon the individual who is Governor of these islands, whose permission it is necessary to procure.

The winds on the west coast of Luconia, in the northeast Monsoon, are oftentimes from the north and northwest, and during the southwest Monsoon it not unfrequently comes from the south to southeast; the land and sea-breezes often prevail, advantage of which is taken by vessels on their passage up and down the coast.

THE SOOLOO SEA AND EQUATORIAL PASSAGE.

As my instructions embraced the exploration of the Sooloo Sea, I endeavored to acquire, during my short stay at Manilla, all the information that was to be had upon the subject. Captain Halcon, of the Spanish Navy, was kind enough to offer me all he possessed, but regretted exceedingly that it was so limited. He had himself been engaged in several explorations or surveys near Manilla, but beyond the Straits of Mindoro, he said, all was uncertain, and little known. I failed also in procuring a pilot who had any knowledge of the general route pursued by vessels bound for Sooloo. Viewing my time as exceedingly limited, it occurred to me that the best course would be to secure a knowledge of the entrances, particularly the Straits of Mindoro on the north, as well as the Straits of Balabac on the west, and Basilan on the south.

Although the route chosen and surveyed by the Expedition was the Straits of Mindoro, on the west of that island, it is not, in my opinion, the best. I should prefer passing into the Sooloo Sea, from the northward, through the Embarcadero, between the island of Luzon and Mindoro, which leads to the east of the latter island: this passage is clear of sunken coral reefs and easily passed through. When up with the east end of Isle Verde, a fair wind may be expected, and the route being free from all obstructions, it may be navigated in the night as well as the day. The Embarcadero is the channel leading to the Straits of San Bernadino; its length is about 50 miles, its average width 10. Intending to take this route, it is necessary to pass to the eastward of Luban Island and turn into it, giving Point Santiago a good berth to clear the Minerva rock, stretching over to the Mindoro side, for the wind will generally be found to draw through the channel from the eastward; consequently it will be a dead beat. Anchorage may be found in Calapan Roads, on the coast of Mindoro, and within the Bacos Isles. It is high water, full and change, at 7 A. M.; the tides flow through with some strength. The south end of the island of Luzon affords many anchorages, which may be used temporarily to await both wind and tide. In this channel lies the Island of Maricoban, the Isle of Verde, and the Bacos and Silunay islands; in their neighborhood it is comparatively narrow, but there is ample room to work a large vessel.

The entrance through the Straits of Mindoro is rendered dangerous by the Apo Shoal. This shoal lies 12 miles from the Island of Mindoro, is of a triangular form, and has several small sand islets on it, and a mile to the west is a small sand island. The longest side of the shoal makes a sweep from west northwest to east southeast, while the two others join, forming a tail at the south. On each side of it there is a clear passage: that nearest Mindoro I have called the Pandan Channel, the outer one has been known as the Northumberland Channel; the former being 10 miles, and the latter 15 miles in width. I much prefer the Pandan Channel. In the event of night coming on, one may anchor with safety in the small bays, which I think is preferable to beating about, subjected to tides, and in danger of being set on a coral rock, or reef, many of which, though of small extent, exist off the south end of Mindoro Island, and render it necessary for large vessels to be very cautious.

After reaching Ylin Island, off the south point of Mindoro, the route is to windward, around the Island of Semerara, before standing over for the coast of Panay: this, though the safer course, is nevertheless attended with delay, and one is greatly tempted to pursue the straight course, and pass directly through the coral reefs and shoals;

but this requires both confidence and self-possession. By keeping a good look-out, however, with a commanding breeze, the gauntlet may be run. The shoals and reefs may be distinctly seen in the morning hours by the color of the water, and avoided.

After rounding the Island of Semerara, it is desirable to steer direct for Point Potol, the north end of the Is and of Panay, and continue down its coast, passing inside of Hat Island of the charts. The winds here will be found generally to prevail from the eastward, and usually, when close to the island, are light, from which direction it blows for the most part of the year.

The coast of Panay, within the line of Banco Seco, and Hat Island, is clear of danger: this gives a good beating channel of about 20 miles in width; but the wind will be generally found favorable when passing either to the north or south along this coast, which trends in the same direction. West winds are sometimes felt as eddy winds when abreast of the high land of Panay: these also will be found of great assistance, allowing a vessel to stand along the land.

After leaving Panay, the west point of Mindanao lies due south, which is the north point to the entrance of the Straits of Basillan. There is nothing to obstruct the navigation. The islands of Negros, Zebu, Bohol, and Leyte, lie to the eastward of this track, and although high, they do not offer any obstruction to the prevailing wind, which will be found steady in passing by them.

At the western entrance of the Straits of Basillan is the small port of Caldera, which offers at all times a safe and convenient anchorage for vessels passing through, and where they may await a tide. To the east of Caldera lies the town of Samboangan, the largest on the island: it is the headquarters or residence of the governor. The anchorage off it is rocky, and exposed to the strength of the tides. A little fruit may be had, but no other supplies of consequence. Vessels touching here are liable to meet with some annoyances in consequence of Spanish jealousy.

The Straits of Basillan offer no difficulties to the navigator, and may be passed through during a tide. There are several sandbanks about one and a half miles off Caldera, with ten fathoms water on them. The chart of this strait will point out all the dangers. The south side is the safest, where anchorage may be found in moderate depths of water. The tides, though irregular as to time of running, set through the Strait, the flood to the northward and westward, and the ebb to the southward and eastward. In the small port of Caldera, their velocity by the log was found to be 2 miles an hour, — but they must be much

stronger than this in the Strait. It is high water, full and change, 9 h. 30 m. A. M.

If the intention is to take the Equatorial passage, steer to the eastward, and when off Point Balota, haul over for Saddle Island, and pass between it and Anapuyan, thence steer for the Serangani Islands, off the south end of Mindanao, and pass to the northward of them, or between them and the Tolour Islands, into the Pacific, and onwards towards the Equator. In case the navigator should prefer it, he may pass to the southward through the Pilas Channel, at the west end of Basillan, into the Sea of Celebes, and thence towards the Tolour Islands. Should the wind be from the northeast, it is advisable to keep as far to windward as possible, to weather the North Cape of the Island of Morty, and allowance ought to be made for the current which sets sometimes through Morty Straits; but most frequently as these straits are opened, it will be found to set to the northward and eastward. When in 2° 30′ north latitude, the westerly wind will be fallen in with, and may be preserved by passing just to the northward of the Admiralty Islands. The winds may prevail at times from the northward and westward, as well as southward and westward. These westerly winds will generally extend as far as the longitude of 170° east. Prior to reaching that longitude, it will be well to borrow towards the Solomon group of islands, passing along to the eastward of them; this may be readily done during the season of the westerly Monsoon, from September to March, but favorable winds will generally be found to prevail during all seasons, and enable the navigator to proceed, without interruption, over a route which has hitherto been deemed impracticable, and which shortens the time and distance between the ports of the China Seas and those of the South Pacific, New Holland, New Zealand, the Pacific Islands, and the whaling-grounds, to which our vessels are continually passing by the circuitous routes around New Holland and through the North Pacific.

The Equatorial route, it will be perceived, is closely connected with the Sooloo Sea, and is advantageous for vessels from the southern part of the China Seas to pursue, passing through the Straits of Balabac, the western entrance to the Sooloo Sea, on a direct course to the Straits of Basillan. The distance of one strait from the other across this sea is but 300 miles, and few shoals to interrupt the navigation; there are many coral banks, but they all have sufficient depth of water to pass safely over them. This route avoids the long calms and strong currents which are met with in the Macassar Strait, and may be followed at any time of the year, while the others are precarious at all times; it is

therefore preferable for vessels bound to the eastward, even during the favorable seasons.

On leaving Caldera, bound to the west, through the Sooloo Sea, we passed directly towards the Island of Sooloo, between Pilas Island and the Sandboys: these last are readily known by the two pointed peaks. This, though a practicable route, cannot be recommended for vessels: it is better to pass to the northward of all this small cluster of islets, from which a direct course, nearly due west, may be pursued to the island of Cagayan Sooloo, which will carry a vessel clear of all the islands and shoals. There are several coral sandbanks, with from 15 to 30 fathoms of water on them, suitable for a vessel of large size to anchor on, in the event of calms, rather than be subjected to the strong tides and cross currents that are found to prevail; indeed, the difficulties which seem most to impede the navigation of this sea, are the currents and light airs and calms of the night hours, when it would be advisable for large ships to anchor, if they are fortunate enough to obtain suitable bottom. I practised this myself to advantage, and felt it a security as well as time gained in saving the distance the ship might have been carried by the tides to the southward and eastward. Unless there is this reason for it, there is no necessity to have recourse to anchoring, as the weather is seldom stormy, or subject to anything more than strong breezes, of short duration. Typhoons have never been experienced; and what is still more advantageous for vessels pursuing this route, they never meet with the rough seas which are encountered in the Palawan Passage or China Seas. After passing beyond the Straits of Balabac, they are in a situation to take advantage of any favorable wind that may offer for the purpose of reaching the Straits of Sunda, if in the southwest Monsoon, either by stretching across the China Sea, or beating down the west coast of Borneo.

If the navigator desires to pass to the west through the Sooloo Sea, from the island of Panay, after having passed the Banco Seco, or abreast of Antique, he may take the direct course between the Cagayanes Islands and the Cayos Islets. The only dangers to be avoided are the Golconda Shoal to the south of this track, and Piedra Blanca to the north, lying south of the Cayos. In all probability a favorable breeze will enable both to be cleared before night, after which there is plenty of open and unobstructed sea to work to the westward in; the direct course is about west southwest. The current will generally be in the opposite direction to that of the Monsoon blowing in the China Sea. This direct track, if intended to be pursued, should be confined to the northward of the small banks and islets lying in the same direction as the Cagayanes, viz., Cabreja, Cavalli, Temerario, Tob, Bataka,

Bancoran, and San Miguel. When up with Bajo Neuvo, both the peaks of Banguey and Balabac will be in sight, and it will be better to steer for the former, with a view of sighting the Mangsee Islands, and passing through that channel, as there are fewer concealed banks than on the north side of the strait.

In consequence of the Monsoons not prevailing in the Sooloo Sea with the same regularity as in the China Sea, there is much greater opportunity of advancing against their directions. They are interrupted by the highlands, lying both to the east and west, which bound this sea. In the months of June and July, fresh gales occur, while in August and September, the winds are usually from the south, sometimes blowing strong. In the months of December and January, north winds prevail. The usual direction of the wind is, however, from the same quarter as the Monsoon, though much less strong, the weather being more or less of the same character.

In the Hydrographical Atlas of the Expedition will be found correct charts of the Sea of Sooloo and its three entrances, viz., the Straits of Mindoro on the north, Basillan on the south, and Balabac on the west; also of the island of Sooloo, and harbor of Soung: these are derived from the best surveys by the Spanish, as well as our own observations; and I think those parts that we were not able particularly to examine may be relied upon.

Vessels leaving Singapore, or the islands of Sumatra and Java, for the northern ports of China, can save much time by passing through the Straits of Balabac. Although the winds may prove unfavorable, yet the current sets on the coast of Borneo to the north, in their favor, and with great velocity. The approach to the Straits of Balabac ought not to cause anxiety. The Peak of Balabac on the north, as well as that of Banguey on the south, are good and distinct landmarks; all that is then required is to keep a good look-out from aloft for the shoals and reefs in the range trending north northeast and south southwest. The passage through the shoals, sailing westward, is best made when the sun is in the east, or during the morning hours, and it is almost needless to say, that when sailing to the eastward, the sun should be, for the same reasons, in the west. I would strongly advise that the Great and Little Mangsee should be run for, as they will afford the necessary landmarks to insure a clear passage, and if desirable, at the setting in of night, a vessel may anchor under them until daylight. A few hours will suffice to clear the dangers, and place a vessel in such a position in the China or Sooloo Seas, that she will be enabled to pursue her route towards the Equatorial passage, or to seek any port of destination whither she is bound, without further anxiety or detention.

For more particular directions, I must refer to the volume on Hydrography, where they are given very minutely.

FROM SINGAPORE TO THE CAPE OF GOOD HOPE

Between the 26th of February and the 13th of April, 1842.

This passage occupied 46 days. On leaving Singapore, I chose the route by the Straits of Rhio, thence to the eastward of Lingin Island to the Straits of Banca, through them to the Straits of Sunda. This I thought the preferable and shortest route. It was taken with a view of examining more particularly the charts extant of these Straits.

Before leaving Singapore, I was permitted to take a copy of a MSS. chart, by the kindness of Lieutenant Dittlof Jassen, of the Royal Dutch Navy, who was then engaged in making a survey of the Straits of Rhio. This I examined carefully, and I am gratified in being able to state the confidence I feel in its correctness, and to vouch for the accuracy of very many of its details.

Leaving Singapore at an early hour, a vessel will reach the entrance of the Rhio Straits before the setting in of the Trades, and may be able to pass through to the southern entrance of the straits before being overtaken by night, particularly, if the tide should serve; in case of detention, it would be well to drop anchor; this may be done anywhere within the straits with safety; the depth ranges from 5 to 15 fathoms; the tide sets in a line with the straits, the flood to the north, the ebb to the south. It is high water, full and change, at the northern entrance of the strait about 10 o'clock; strength of the tide from 1 to 3 miles per hour. In rounding Lingin Island, if at night, it would be advisable to give it a berth of from 3 to 4 miles, and pass around it in from 15 to 18 fathoms depth of water. After passing Lingin Island, if it is thought preferable, the route by Gaspar's Straits may be taken; in the season of the northeast Monsoon, this may be preferable to that by the Straits of Banca, as the wind will be more likely to hold, and the route may be pursued during the night. There are some shoals in these straits which have been recently examined by the late surveyors, — their positions are now well ascertained; the east or west channel may be taken according to circumstances; accidents in passing through these straits ought to be imputed more to carelessness than the want of good charts and directions.

The sailing directions for Banca Straits as given by Horsburgh, were found in the main correct — the only difficulty is in the Lucepara Passage after nightfall; there are many places of shoal water, but the bottom is soft, and not much danger is to be apprehended.

I should recommend always anchoring on the approach of night, while in the straits; after getting through the Luccpara passage, we found good anchorage under the Two Brothers—the next night anchored off North Island, and the day after reached Hout's Island, at the entrance of the Straits of Sunda; here we also anchored, owing to a loss of wind and being left to the action of a strong tide; on its making in our favor with a light breeze, we proceeded round Zutphen's Island and Hog Point, and anchored off Rajah Bassa. The weather was what is usually experienced at the end of the northeast Monsoon, cloudy, with light winds during the day, and thunder-squalls with copious rains during the night. We left the Straits of Sunda between the islands of Pulo Bessy and Crockatoa, with the wind from the eastward; but we had not been long in the Indian Ocean before we encountered the northwesterly Monsoon, with severe squalls, accompanied with lightning and rain. This kind of weather, with strong winds, continued until we reached the latitude of 14° south and 100° east longitude, and may be expected to prevail towards the end of the Monsoon; the northeast Monsoon of the China Seas, is identical in point of time with the northwest Monsoon of the Indian ocean, and during the southwest Monsoon of the China Sea, the southeast Monsoon prevails; while the northeast Monsoon is the dry season, the northwest is the rainy; and while the southwest Monsoon is the wet season of the China Seas, the southeast Monsoon is the dry one of the Indian ocean. Yet this is not the case throughout this sea, but more particularly applicable to the weather coast, the lee coast being generally subject to great drought during the same periods. We found the limits of the northwest Monsoon to continue farther to the south than usual, to the 14th parallel of south latitude; and they frequently extend to the northward of the Equator as far even as 5° north; but the usual limits are within the latitude of 11° south and the Equator.

The passages to and from China have been much shortened by the enterprise of our ship-masters, and the superior class of ships that are now built for this trade; in consequence these vessels pursue a much more direct route, and instead of making the long detour recommended by Horsburgh and others, in contrary Monsoons, keep within the variables of the Indian ocean, until they can steer a direct course towards the Straits of Sunda, and thence beat up the China Seas against the Monsoon; indeed so much difference is there in the length of the passages that a clipper ship will almost go and return by the new route, before another of the old model could accomplish the distance to China by the eastern passage.

The passage home from the Straits of Sunda is a very simple navi-

gation. On leaving the straits, during the prevalence of the southeast Monsoon, steer direct to the southwest, as the winds will be favorable; but when the northwest Monsoon prevails, the course is to the southward, to reach the southeast Trades as soon as possible; these will generally be entered about the latitude of 10° or 12° south, when the latitude in which they prevail with the greatest strength is to be kept, this is generally between 12° and 20°; the parallel of 15° may be preserved, unless it is in the hurricane months, from December to April, during which period it is advisable to give Mauritius and Bourbon Islands a wider berth, experience having shown that these storms take place more frequently and with more violence in their neighborhood than elsewhere. These gales are represented as more violent than those which occur in the West Indies, but the accounts are probably somewhat exaggerated; the precautions advised by Horsburgh and all those who have written upon these storms, or the typhoons of the China Seas, cause them to be looked forward to with more anxiety than is necessary. The barometer gives timely notice of their approach by rising somewhat higher than its ordinary standing, then falling gradually, the sky becomes overcast and lowering, with much lightning in the northwest. On encountering a swell from the northward, with these appearances, in the Indian ocean, it may be some indication that a storm is approaching, and all the necessary steps should be taken to make ready for what may be expected in a few hours; if, however, the swell should be perceived coming from the southward or westward, I think it may be considered an indication that the storm has passed, and no apprehension need be entertained. A recurrence of these storms of any magnitude seldom takes place in the same season.

The axis or centre of the storms of the Indian ocean describe an ellipse towards the southwest in their onward course to the west, the wind veering being from left to right, instead of from right to left.

In navigating towards the Cape of Good Hope, it is to be remarked that the longer a vessel can keep within the strength of the Trade Wind, the greater is the probability of shortening the passage. It will therefore be more advantageous to pass at other seasons than those subject to hurricanes, nearer to the Mauritius and Bourbon. From December to April is the season of hurricanes; during the rest of the year they do not take place: these islands then may be approached without apprehension. Yet in steering to the west, after passing these islands, it is to be considered whether the coast of Africa ought to be sighted, as calms and southwest winds prevail at the entrance to the Mozambique Channel, particularly during the summer of the southern hemisphere.

In passing the Cape of Good Hope with a view of stopping there, the cold water on the Agulhas Bank will be entered. The use of the thermometer in navigation is now well known and admitted; had it been known formerly, there is no place where it would have saved more lives than in rounding the Cape of Good Hope. If the thermometer is used, it will give timely warning, and should claim attention, whatever confidence may be put in the position of the ship. All that is necessary in passing the Cape is to preserve the temperature of the water above 70°, which is the temperature of the current setting to the southwest, and which will carry a vessel quickly to the west. The water on the Agulhas Bank is always below 70°, or a few degrees below the temperature of the surrounding ocean, and if due attention is paid, the land cannot be reached without noticing it; no possible danger can occur. When bound into Table Bay, keep within the cold water: the current will carry a vessel to the northward along the coast. When up with it, steer for Green Point, and into the bay, where good berths are found to anchor in before Cape Town. The bay is almost an open roadstead, but dangerous only in the event of a northwest storm, in which case the whole anchorage is open to the ocean, when heavy seas roll in with great force. The periods of the year when it is deemed an unsafe anchorage is during the months of April and May.

CAPE OF GOOD HOPE TO ST. HELENA AND THE UNITED STATES.

Between the 17th of April and the 9th of June, 1842.

If vessels do not intend to touch at the Cape of Good Hope, they of course will keep in the warm current until it is passed, and then direct their course towards St. Helena or Ascension. It is preferable to give the Cape a good berth, by which course the winds will be less variable and the southeast Trades be entered sooner, not being affected by the influence of the Cape winds. These may be looked for on the parallel of 30°, in the longitude of 10° east, which meridian will seldom be passed before the Trades are entered; then a course may be steered to cross the Equator in the longitude of 30° west, thence to strike the Gulf Stream on about the 73d meridian west, on the parallel of 30° north. In this route there is almost a certainty of preserving a fair wind the whole distance. The southeast and northeast Trades will be more or less fresh, according to the season of the year. They may become light, yet they will be favorable; in our voyage we passed from the one to the other without an hour's calm, with the aid of a breeze from the south southwest; if, however, they should, as the Equator is approached, be found from the northward and light, it is advisable to

keep a good full, trusting without fear, as westing is made, the wind will enable a vessel to come to her proper course. The only difficulty in this long navigation is to avoid the calms in the North Atlantic, by passing to the west of them; they lie between the latitudes of 28° and 32° and east of the meridian of 73°. The wind will generally draw towards them from the southwest. The northeast Trades will be held longer to the west; therefore a navigator ought not to be too anxious to maintain an inflexible purpose of sailing on a loxodromic curve: a deviation to strike the Gulf Stream to the south of Cape Hatteras, to take advantage of the winds which prevail on our southern coast, is the best, and will insure the help of that current. After getting into the Gulf Stream, the passage can only be retarded by the local weather of our coast. In the spring and summer of the year, southwest winds prevail; in the autumn and winter, easterly as well as northwesterly winds are prevalent. These ought to be considered by the navigator when about to make the coast and shape a course for his port of destination.

THE END.

MAP
OF THE WORLD
SHEWING
THE EXTENT AND DIRECTION
OF THE WIND
AND THE
ROUTE TO BE FOLLOWED IN
CIRCUMNAVIGATION OF THE GLOBE.
BY CAPT. CHARLES ROBERTS.
NORTH AMERICA
EUROPE
ASIA
SOUTH AMERICA
AFRICA
AUSTRALIA

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